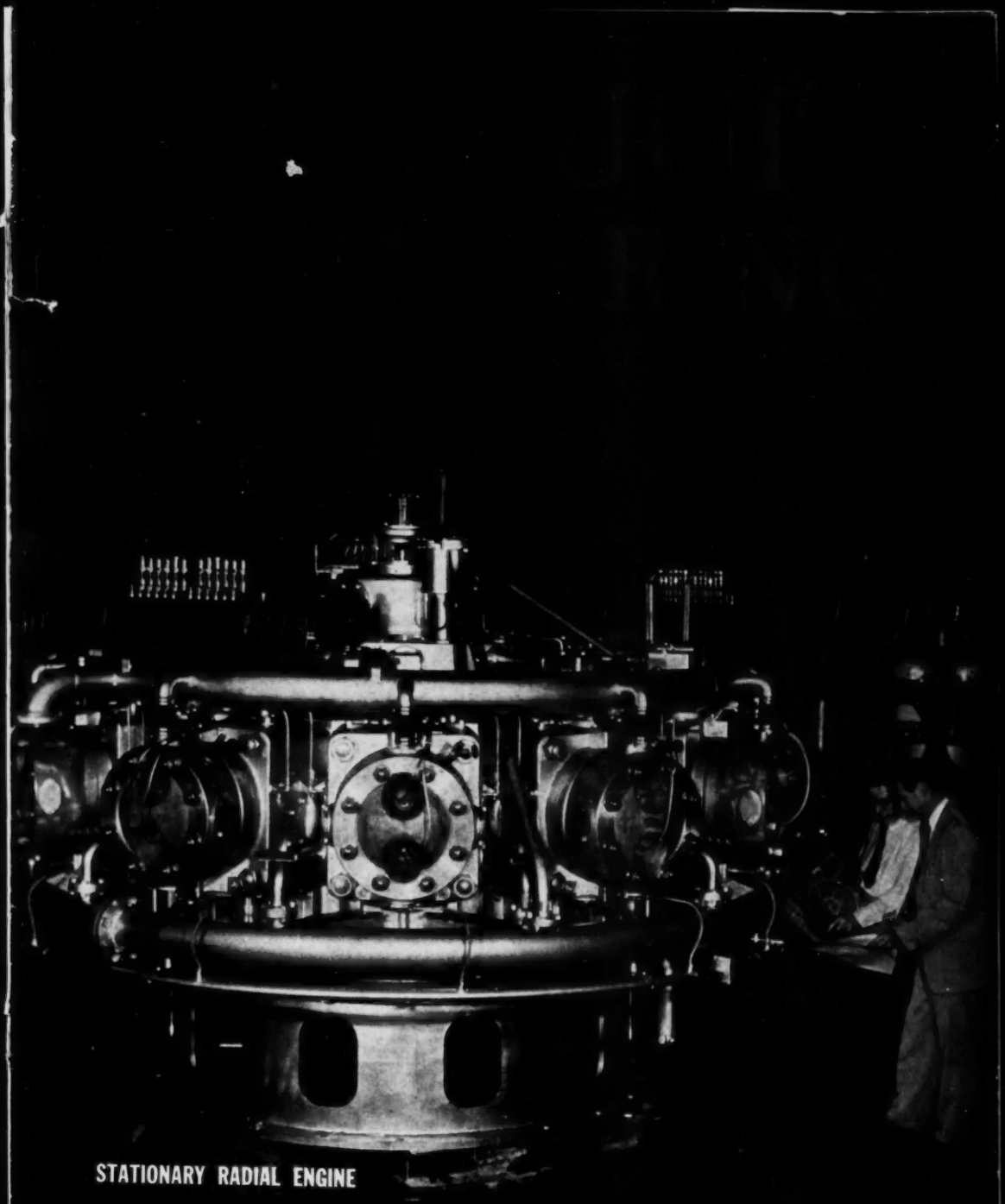
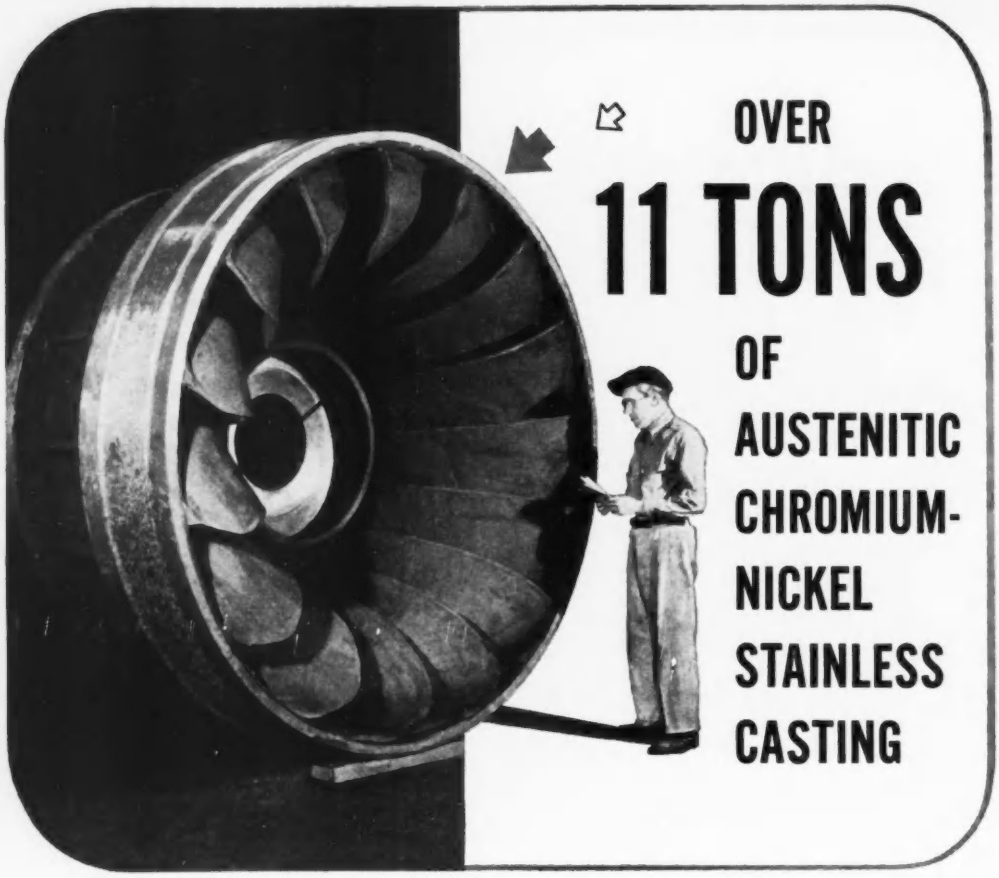


STATIONARY RADIAL ENGINE



OVER 11 TONS OF AUSTENITIC CHROMIUM-NICKEL STAINLESS CASTING

Size and complexity are not limiting factors in casting stainless chromium-nickel steels. This 22,800-pound turbine wheel is believed to be the largest casting of its type and composition ever produced.

Produced by The Midvale Company, Nicetown, Philadelphia 40, Pa., for Allis-Chalmers Manufacturing Co., Milwaukee 1, Wisc., this casting is of the "18-8" type. It is only one of many applications in which austenitic chromium-nickel stainless steels provide the utmost in long, dependable performance under corrosive and erosive conditions. The unique combination of properties offered by stainless steels merits your consideration of this material when designing new products or improving old ones.

EMBLEM OF INCO SERVICE

Over the years, International Nickel has accumulated a fund of useful information on the properties, treatment, fabrication and performance of engineering alloy steels, stainless steels, cast irons, brasses, bronzes, nickel silver, cupro-nickel and other alloys containing nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

VOLUME 20 — PRODUCT ENGINEERING — NUMBER 11

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FRONT COVER — Radial design applied for the first time to a stationary industrial engine. Conversion can be made to gas, diesel or combination fuels. See page 92 for design features. Kodachrome courtesy of Nordberg Manufacturing Company.

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Publication Office: 99-120 North Broadway, Albany 1, N. Y. Return postage guaranteed.
Published Monthly by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948), Founder; James H. McGraw, Jr., President; Curtis W. McGraw, Vice-President and Treasurer; Eugene Duffield, Senior Vice-President, Publications Division; Nelson Bond, Vice-President and Director of Advertising; Joseph A. Gerardi, Secretary; J. E. Blackburn, Jr., Vice-President and Director of Circulation.
Correspondence About Subscriptions should be addressed to Director of Circulation, Product Engineering, 330 W. 42nd St., New York 18. Allow at least 10 days for change of address. Indicate position and company connection on all subscription orders.

Subscription Rates: Single copies 75c. United States and possessions, $6 for one year, $9 for two years, $12 for three years; Canada, $7 for one year, $11 for two years, $14 for three years; Latin American countries, $10 for one year, $18 for two years, $20 for three years; all other countries, $15 for one year, $25 for two years, $30 for three years.
Editorial and Executive Offices: 330 W. 42nd St., New York 18. Cable address: "McGraw-Hill." N. Y.
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Entered as second-class matter Aug. 21, 1936, at Post Office, Albany, N. Y., under act of Mar. 3, 1879. Printed in U.S.A.
Member of A.B.P., A.B.C.
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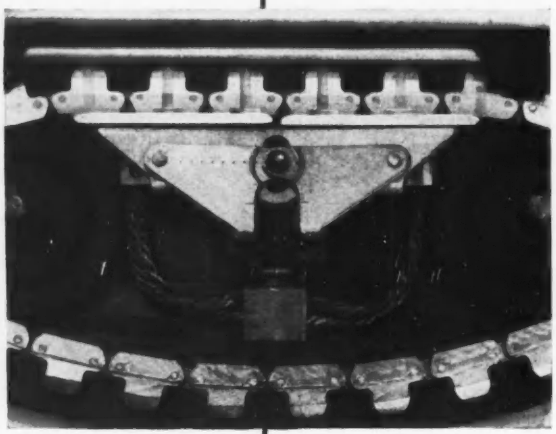
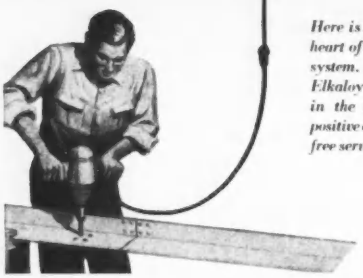
In the BENBOW "Trac Troly" Safety Conductor Systems MALLORY METALS outperformed all others by better *than 10 to 1!*





Here is a phantom blow-up of the heart of the Benbow "Trac Troly" system. Note the way Mallory Elkaloy contacts have been inserted in the collector chain teeth—for positive contact that will give trouble-free service as long as the unit lasts.

—"we are simply elated with the increase in performance we have had with the Mallory contact design!" That's the way Benbow writes after months and months of grueling use.

Their "walking" mobile electric system with chain teeth supplies a *completely safe* method of electrifying portable tools and hoists. But Benbow *did* have a tough problem in making its unique current collector and "trac troly" system as long-lasting and trouble-free as it was different. So, Benbow turned to Mallory for its experience and tough metals that had *high conductivity* plus *longer wear resistance!*

Both Mallory engineers and metals came through with flying colors. By using Mallory 3* Metal shoes and Elkaloy* A contacts on each of the collector chain teeth, Benbow achieved "excellent results on the toughest installations."

This case history is added proof that you can't beat Mallory's resources and skills in the special metals field. Write Mallory today concerning *your* problem. Let the engineers that helped Benbow help you!

*Reg. U.S. Pat. Off.

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Highlights

In this summary of technical developments, space restrictions do not allow giving complete details. Further information relating to any item can be obtained by writing to the Editor of Product Engineering.

Metallic Materials

ANNEALED COPPER POWDER mixed with cellulose dope is more economical to solder than alloys in the conventional rod, wire or sheet form. Same powder mixed with a borax flux results in similar savings when brazing hard metal tips to tool shanks. Method lends itself to joining irregular surfaces.

NEW LEAD ALLOY for plating and process tanks outlasts the present 8-percent antimony composition as a corrosion inhibitor. Cost savings realized over the long haul may be enough to stem the tide of conversions to rubber or ebonite linings. Tubular sections of the new material can be used for plating anodes, as well as cooling coils.

HIGH YIELD STRENGTH, both in compression and tension, is the key property that aircraft designers require of wrought aluminum alloys. Growing tendency to use thin sheet for resisting compressive stresses in aircraft has brought about the belief that heat-treatable alloys of the high Cu-Mg-Zn-Al type may be able to handle tensiles up to about 100,000 psi. Above this figure, beryllium and titanium may become competitive.

SPRAYED ALUMINUM AND ZINC are reported to be the most economical mediums of protection for metal surfaces subject to accelerated atmospheric corrosion. Aluminum is doing yeoman service on railroad cars and steel mill superstructures; zinc on ship hulls and bridge components.

NICKEL ALLOY, devoid of copper and iron, is highly corrosion resistant, has good machining properties. Reported to have complete freedom from seizing or galling when in moving contact with itself or other metals, including stainless. Comes in cast form only; does not require heat treatment. As-cast tensile strength is 50,000 psi; elongation, 7 to 10 percent; Brinell hardness, 145 to 165 (3,000 kg load).

MACHINE PARTS pressed from stainless steel powders are getting the nod in applications in which contamination cannot be tolerated. Small cams are already in production and parts having surface areas of 24 sq in. and larger are under study.

Nonmetallic Materials

GASKET MATERIAL that resists oil and temperatures to 500 F is composed of Fiberglas cloth coated with silicone rubber. Sheet thicknesses vary from 0.013 to 0.020 in. Already used for sealing aircraft engine rocker boxes, material has promise of wide application in the internal combustion engine, marine and related industrial fields.

CHEMICALLY TREATED PAPER wrapped around metal parts keep them free of rust for three to five years. Impregnant vaporizes slowly and maintains, in the package, an atmosphere that prevents corrosion even in the presence of some water.

FLUORINE is being tried for a variety of new uses. The gas may help lubricate supersonic aircraft and guided missiles; the liquid may transfer heat, fill hydraulic systems and fire extinguishers; the solid compound may act as a hose material in fuel and oil systems, also as a non-corrosive filter medium for highly active chemical reagents.

FLAME RESISTING FLUID for hydraulic systems, welding machines, mining equipment and die casting processes does not give off noxious fumes at elevated temperatures, has high lubricity, good corrosion resistance, and is priced lower than comparable formulations.

Continued on Page 5

GLEASON BEVEL GEARS

Builders of Bevel Gear Machinery for Over Eighty Years

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SMALL MAGNETIC COMPACTS of ferrite crystals outdo many powdered iron materials, volume for volume. By varying the amounts of of Ni, Zn and Cu oxides in the sintered mixture, the Curie temperature, at which magnetic properties disappear, can be varied from 90 to 280 C. Uses to date of lightweight material include transformer cores, deflection yokes, magnetic accelerators and tubular antennas.

WATER-PROOF ADHESIVE requiring no heat or pressure during application bonds to rubber, metal, cork, concrete, glass, wood, plastics, tile and asbestos.

Processes

ONLY FIVE SECONDS are required to temper surfaces of small metal parts like ratchet wheels. An electromagnet holds part in the field of a powerful electronic heater. When proper temperature – 1,600 F, for example – is reached, magnet and heater currents go off automatically, allowing part to drop into cooling bath of oil.

ABRASIVE BLASTING of clean die castings has threefold benefits – reduces porosity through cold working the surfaces, removes flash and burrs, and prepares the surfaces for for subsequent coatings.

A MIRROR-LIKE LUSTER is produced on the surfaces of nickel, copper alloy, monel and aluminum parts in one simple dipping operation. Time of immersion in a mixture of basic acids varies from 10 sec to 10 min, and temperatures range from room to 200 F, depending on the initial surface conditions and degree of polish desired. Steel and die-cast metals cannot be treated in this manner.

METAL CASTING PROCESS simultaneously casts, molds, forges and coins metal parts to finished dimensions and does away with 60 to 70 percent of the machining normally required in such operations. Metals including aluminum steel and copper alloys can be formed by this process that is reported to achieve improvements in tensile and yield strengths of 10 to 40 percent. Tolerances of 0.001 to 0.002 in. can be held.

FINISH FOR ZINC DIE CASTINGS used on exterior of late model cars is a triple plating consisting of 0.0005-in. layers of copper and nickle followed by a 0.0001-in. film of chromium. Surface satisfactorily withstands atmospheric corrosion and tarnishing agents

Products

LARGEST PRECISION HYDRAULIC PRESS for conveyor belts weighs 310 tons, has platens 40 ft long that handle belts up to 72 in. wide. During the vulcanizing process, the temperature of platen surface, equal in area to that of a bowling alley, is kept constant to within 2 F by eight synchronized controllers.

TALKING DICTIONARY correctly pronounces any word in any language. When positioned in proper groove according to first letter of chosen work, a selector head engages one groove on a dictaphone-type master cylinder. Chosen word then appears in window above the cylinder and the sound of the word is heard over and over until machine is stopped or head is removed.

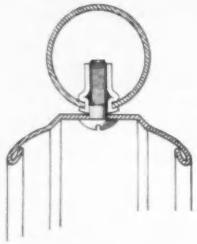
BRIGHT, NON-GLARING HEADLIGHT for cars has a ring just behind the front lens. Silvered strips supported by this ring are tilted like slats in a venetian blind so that most of the light from the bulb is directed forward. Remainder of the light is thrown upward and sidewise, resulting in non-glaring general illumination.

FAST MAIL-LICKER seals 7,200 folded mailing pieces every hour. Pressure-sensitive cellophane tape in rolls from 1/4 to 1/2 in. wide does the job. Machine handles paper in sizes up to 2 x 13 in. Operates automaticly until paper runs out.

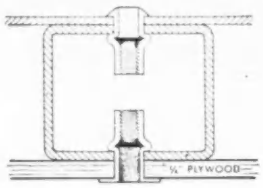
AUDIO-VISUAL SIGNALLING without annoying key clicks characterizes the Chime-Matic intercom system. Push a button and a call is announced by a modualted chime and signal light. Electronic voice circuits "frame" the human voice, cutting out background noise, and make it easily recognizable.

Continued on Page 7

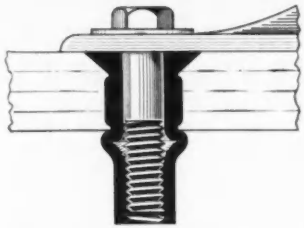
RIVNUTS solve tough fastening problems



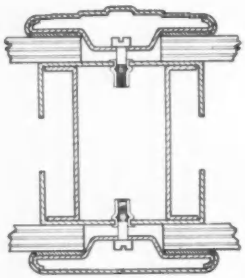
1 **TO ATTACH A MUDGUARD** to a bicycle's tubular frame, designers used a standard flat-head Rivnut. The correct radius was ground into the anvil of the heading tool, which curved the Rivnut head at the same time the bulge was formed. The still-intact Rivnut threads provided a firm anchor for the attachment screw.



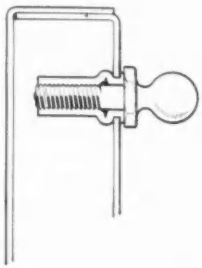
2 **RIVNUT AT BOTTOM** (above) fastens plywood walls to tubular steel sections in trailer. Large washer head and bulge in shank prevent Rivnut pulling through plywood or vibrating loose. Rivnut at top rivets steel sheet to opposite side of section. *One man* can install a Rivnut from one side of work *in two seconds*.



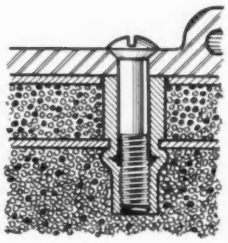
3 **BUS DESIGNERS** used Rivnuts—*the only one-piece blind rivet with threads*—to fasten seats to plywood floor board. Heading tool upset Rivnut, forming bulge under floor board. Splines on Rivnut shank took care of torque. At least 6 Rivnut threads remained clean to grip attachment screw. Many man-hours were saved in assembly.



4 **THE PORCELAIN STEEL WALLS** of this pre-fabricated building are securely fastened, yet easily removable for moving or repairs—thanks to Rivnuts. Installation is made by one man from one side of studding. Rivnuts require only very small hole, provide wide bearing surface. Cap screws threaded into Rivnuts attach walls.



5 **THREE PROBLEMS WERE SOLVED** by Rivnuts in this kitchen cabinet door. (1) Rivnut was installed from one side only, (2) It furnished at least 6 clean threads for attaching knob, and (3) It was installed *after* enameling without marring the finish. Rivnuts improved product quality, saved many man-hours on this job.



6 **WALK-IN REFRIGERATOR** uses special-type Rivnuts to attach hinges to door made of steel sheets and sponge insulation. Spacer head allows upsetting of Rivnuts deep in door. Rivnuts form compression fit which—combined with closed Rivnut end—provides positive sealing. Clean threads take hinge attachment screws.

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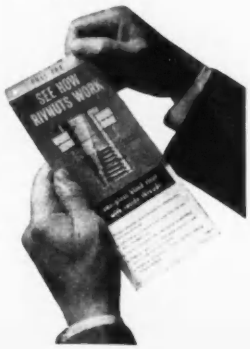
RIVNUTS

The only one-piece blind rivet with threads

SEND NOW FOR FREE RIVNUT DEMONSTRATOR

Have a fastening problem? Get the help of Rivnut engineers. Ask also for free demonstrator that shows with motion how Rivnuts work. Explains construction. Gives applications. Write to The B. F. Goodrich Company, Dept. PE-119, Akron, Ohio.



SIMPLICITY of operation and freedom from interference are features of Sylvania's new television receiver, their first venture in this field. Pictures are automatically "locked" in synchornization both vertically and horizontally. Contrast range remains practically constant even with a change of as much as 5,000 to 1 in signal strength.

Components

WITH THE AUTOMOBILE INDUSTRY well under its belt, the torque converter may start making a dent in the earth-moving, hoisting,

industrial locomotive and rail car fields. According to one authority, the hydraulic transmission's ability to assimilate sudden changes in load and speed will make it possible to design power shovels that perform with the same circular scooping motion as that of human workmen.

SODIUM-COOLED EXHAUST VALVES are now standard equipment for a full line of truck engines. Made of Silcrome-X steel and faced with Stellite, the aircraft-engine-proven parts can withstand temperatures to 1,900 Fahrenheit.

HIGH-FIDELITY RADIO SPEAKER has a dual-cone vibrating system that produces true sound reproduction over range from 40 to 12,000 cps. A 2-lb Alnico V magnet has pole pieces and yoke arranged so that magnetic paths form a bridge network to provide equal flux density for two separate air gaps.

TWO TYPES of cooling-system filter reduce sludging and overheating of automobile engines. One contains a chemically activated element that softens and cleans the coolant; the other removes sludge, grease and scale. When the latter is filled, a red ball becomes visible and a by-pass valve opens.

COPPER FINS embedded in the stator laminations of totally-enclosed, fan-cooled induction

motors extend beyond the core iron and conduct heat to the external cooling air. Additional copper fins at each end around the windings form cylindrical heat exchangers. Motors of this design require little more installation space than do open-type units of the same rating.

SPIRAL-WOUND FACINGS made of asbestos-metallic yarns match specific clutch actions that characterize different clutch designs. Material is flexible for easy installation; reduces torque variation and chatter under wide range of temperature and load conditions.

LONGER LIFE is predicted for engines in the 1950 Nash. Special feature is a new oil con-

trol ring, the lowest of four on the pistons. The flexible assembly derives its oil-wiping action from U-shaped sections placed end to end. Tiny radial slots, 0.001 in. wide, channel oil to the upper portions of cylinder barrels.

Testing

REFLECTION-TYPE FILTERS restrict measurements in the infrared spectrum to a selected band of wave-lengths without using expensive spectrometers. Filters are mirrors that produce interference fringes similar to a soap film, but with increased brilliance.

TWANGING MACHINE simulates flexures that a tire cord or belt encounters in actual use. An electromagnet and voice coil "strum" a cord as it is stretched. Energy converted into heat is then measured electronically.

THE SONIC BARRIER has been breached by the Navy's Skyrocket jet plane. Bird-like in appearance and spanning only 25-ft. the Doug-

las-designed speedster reached Mach 1.03 in level flight at 26,000 ft – a speed of 710 mph. Design capacity of the craft is 1,820 mph at 75,000 feet.

THE "MEMORY SYSTEM" of the Mark III computor can store 64,000 digits, multiply two 16-figure numbers in a fraction over twelve thousandths of a second. Problems are fed on a magnetic tape to a sequencing drum. "Commands" from this drum are then represented as magnetic spots on eight storage drums. Recording heads finally scan these spots as they rotate at 150 miles per hour.

MINUTE QUANTITIES of sulphur and its compounds can be detected with the Titrilog. Sensitive to one part in a hundred million, device is already monitoring natural gas lines.

Left—5 of the 55 pieces of luggage in the smart Samsonite line. All are now equipped with lustrous, solid brass fittings to make Samsonite Luggage look better longer.

Samsonite Luggage

SWITCHES TO SOLID BRASS FITTINGS . . . TO MAKE THE "WEAR SPOTS" ON ITS LUGGAGE STAY SMARTER LOOKING LONGER.

Revere Brass Strip selected for its unusually fine, uniform grain after hardware is formed.

● The name Samsonite has become synonymous with quality luggage the country over. It has a reputation to uphold. For that reason, when the brass plated fittings with which this luggage was initially equipped, started to tarnish and show signs of premature wear, the Samsonite people did a double-take. After consulting with their own engineers and the Revere Technical Advisory Service it was decided that nothing less than solid brass would be in keeping with so fine a line of luggage. Revere Brass Strip, because of its very fine uniform grain, was selected for the job.

Samsonite was extremely pleased with the results. They found that after the luggage hardware was formed it had just the lasting, lustrous quality they were looking for. A fitting companion for the smart Samsonite cases. Now, all external hardware and the internal fittings, where rusting would be detrimental, are of solid brass. Even the keys, usually stamped, are of solid brass, coined and milled.

Perhaps Revere Brass or some other Revere Metal can be of help in improving your product—cutting your production costs. Why not tell Revere's Technical Advisory Service about *your* metal problems? Call the Revere Sales Office nearest you today.

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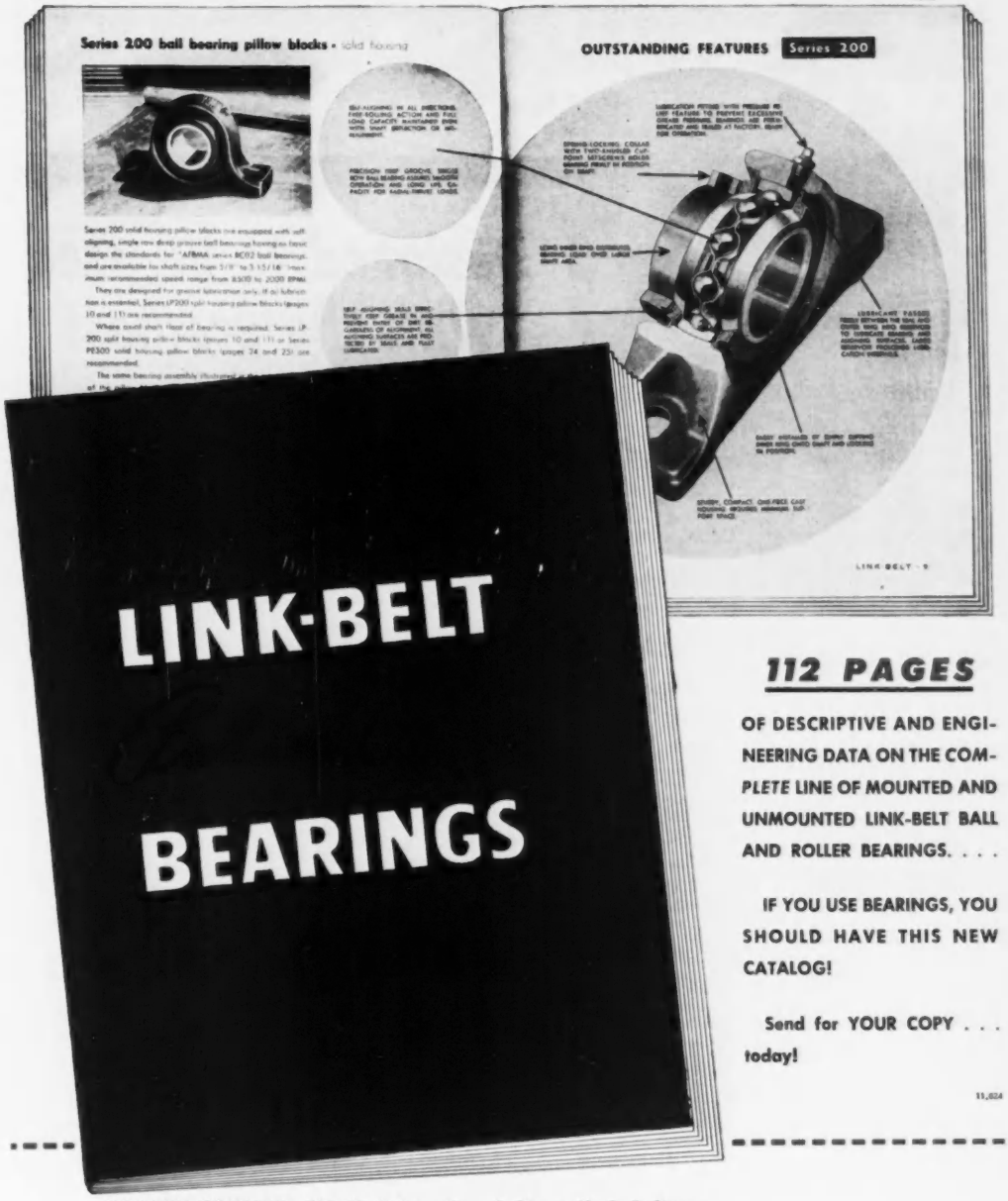

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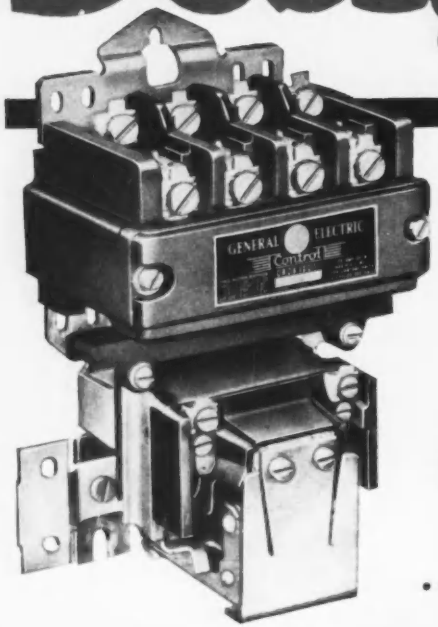
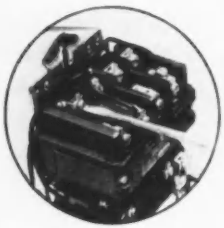


Designed to be used with the greatest of ease!

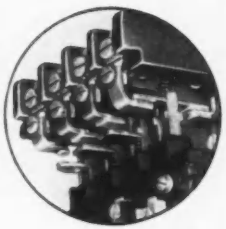
Magnetic Contactors

...in a complete, all-new line



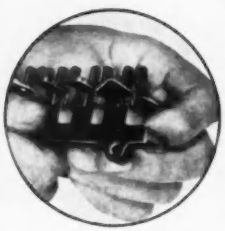
EASY TO WIRE

All terminals can be reached from the front; large pan-head screws give ample bearing surface for screwdriver. Just strip wires, slide them under terminal clamp which rides out with the screw, and tighten screw. These new G-E a-c contactors are available in NEMA sizes 00, 0, 1, 2, and 3, rated up to 50 hp at 440 volts.



EASY TO INSPECT

By loosening two captive screws to lift off the burn-resistant arc hood, you quickly, completely expose the contacts, simplifying inspection and maintenance. All contacts can be removed without disturbing connections to terminals. A screwdriver is all you need for inspection.



EASY TO CHANGE CONTACTS

In sizes 00, 0, and 1, contacts can be changed from normally open to normally closed (or vice-versa) with no extra parts. Just remove two screws and take out the moving contact head. Then depress the spring slightly (it's held in place permanently), roll out and reverse the contact.

EASY TO CHANGE INTERLOCKS

To meet individual control circuit needs, interlocks in all sizes can be changed from normally open to normally closed, just like the main contacts. Extra double-circuit interlocks with interchangeable contacts are quickly added to either side of the contactor. This means four extra interlocks! See Bulletin GEA-5154.

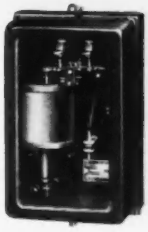
GENERAL ELECTRIC

Digest

PRODUCT HIGHLIGHTS

SENSITIVE RELAYS

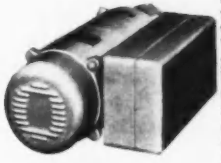
FOR MANY OPERATIONS!



Need a highly sensitive, extremely accurate device to control, protect, or regulate an operation? You'll find the right one among General Electric's standard Type GTR a-c and d-c relays. Unlike ordinary relays, these devices are made to operate on minute frequency, voltage or current changes in a circuit, and, where necessary, to initiate corrective action. Enclosure is dust-tight and moisture proof. See Bulletin GEA-2961.

AMPLIDYNE PLUS AMPLIFIER

EQUALS BETTER CONTROL!

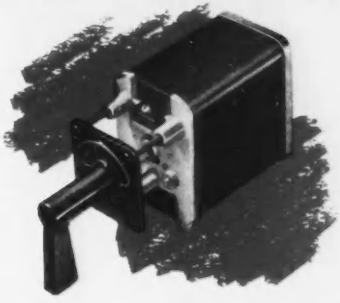


Note the many ways the General Electric electronic amplidyne can help in many types of motor control where you need precise regulation of current, voltage, and speed. With this versatile packaged unit, you can cover wide speed ranges, limit loads, hold tension, speed up acceleration, and position accurately. Providing instant response and high amplification, the G-E electronic amplidyne can be applied to the control of motors from $\frac{1}{4}$ hp to 200 hp. See Bulletin GEA-4889.

STURDY SPACE-SAVER

—THE SIZE 2 SWITCHETTE!

Where space is limited, use this compact, sturdy General Electric Size 2 Switchette to control small-motor drives, for limit-switch applications, and in various electronic, industrial heating, and other control circuits. Approximately 2 x 1 x 1 inches, it weighs only two ounces. Snap action, double-break-contact construction gives it a current rating up to 25 amperes at 230 volts a-c or 24 volts d-c—makes it withstand severe vibration. See Bulletin GEC-207.



Switch to the Switch

WITH 10,000 USES!

Yes, more than 10,000 circuit combinations and operation sequences are possible with this versatile control and tranfer switch—the General Electric Type SB-1. Because its many *standard* cams, contacts, fingers and other parts are interchangeable, you can use it for practically any control job on almost any low-capacity circuit. Construction features include silver-to-silver contacts, anti-arcing barriers between adjacent circuits, and sturdy Textolite face plates.

For extra-heavy duty, the rugged Type SB-9 has all these features plus wear-resistant extra strength built into every part—contacts, gears, shunt connections, and even the handles.

Both the SB-1 and SB-9 mount on panels $\frac{1}{8}$ to 2 inches thick, are rated up to 20 amperes at 600 volts a-c or d-c. And standards are ready on only four weeks' delivery! See Bulletins GEA-4746 (SB-1), and GEA-4114 (SB-9).

General Electric Company, Section F668-76
Apparatus Department, Schenectady 5, N. Y.

Please send me the following bulletins:

- ☐ GEA-2961—Type GTR relays
- ☐ GEA-4114—Type SB-9 switch
- ☐ GEA-4746—Type SB-1 switch
- ☐ GEA-4889—Electronic amplidyne
- ☐ GEA-5154—A-c motor contactors
- ☐ GEC-207 —Size 2 switchette

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DESIGN LEADERSHIP

Ingersoll Nine Station Machine
—(partial view) milling and boring cylinder blocks.

SQUARE D MOTOR CONTROL operates every automatic machine tool in this New automotive engine plant

These pictures show only a few of the tremendous battery of Square D controlled machine tools in one of the country's newest and most modern automotive engine plants.

There are sound reasons for selecting Square D. Unusual completeness of line satisfies virtually any AC or DC application requirement. Standardized components, each designed to perform a specific control function, are all physically proportioned to make up compact, attractive control panels. There is no wasted space—yet there is complete accessibility for speedy inspection and maintenance. Square D control is designed for machine tool service.

***Write** for Machine Tool Control Bulletin 207 describing Square D's complete line.*
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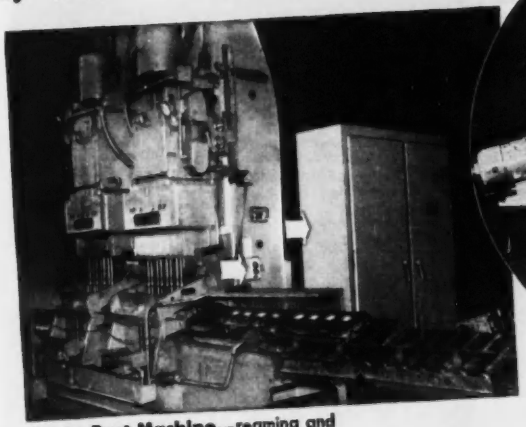
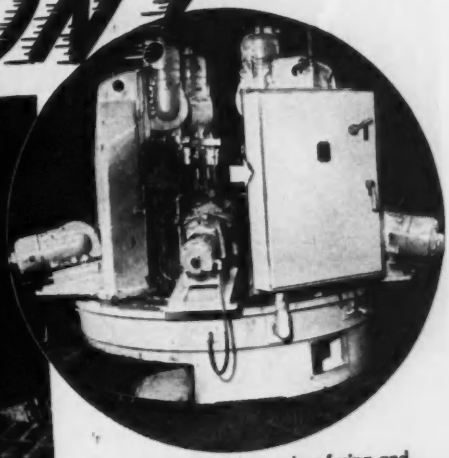
IN ACTION

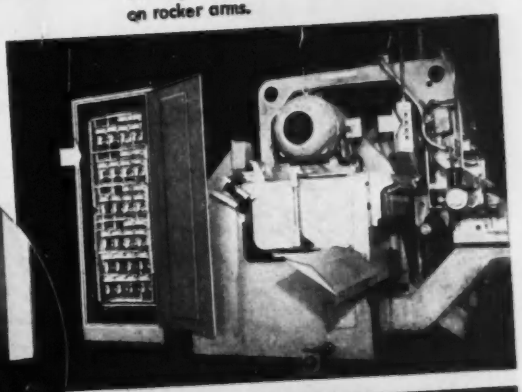


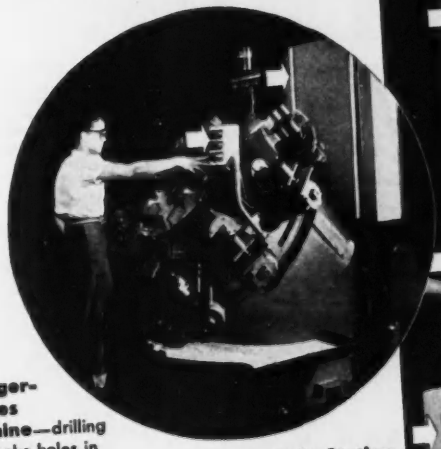
Foote-Burt Machine—reaming and facing valve guides in cylinder heads.



Kingsbury Machine—chamfering and forming ball seat, and drilling oil hole on rocker arms.

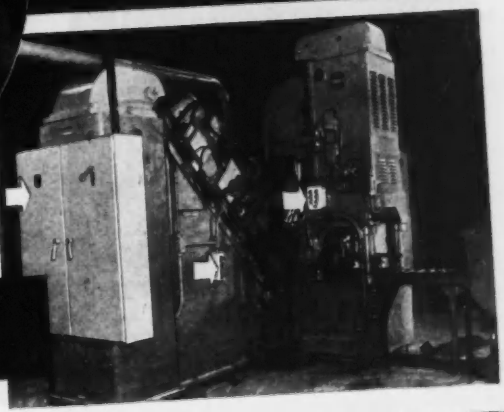
Cincinnati Mill-Broach Machine—milling and broaching cylinder heads.

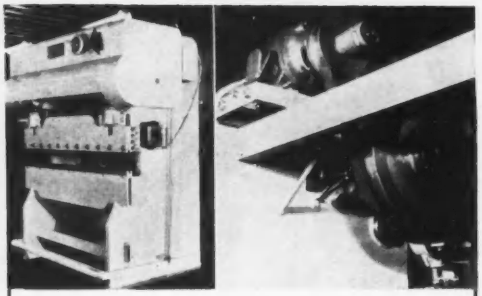




Krueger-Barnes Machine—drilling 12 smoke holes in piston oil ring groove.

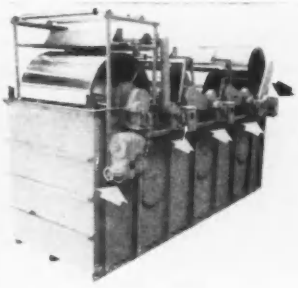
Baush Eight Station Machine—drilling and reaming cylinder blocks.



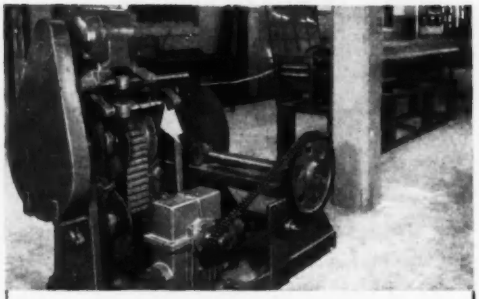


1 REEVES widens the work range of machines—to handle more shapes, sizes, materials. Example: REEVES Vari-Speed Motor Pulley (right) on press brake (left) enables operator to vary ram speed, in bending, braking, punching and other operations, when parts of varying size and weight are in production.

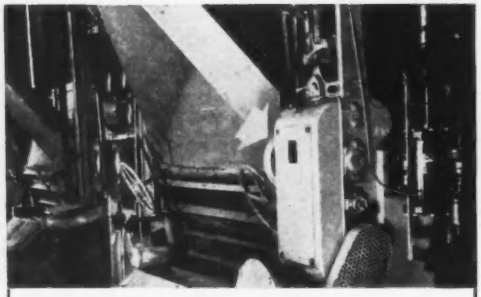
2 REEVES accurately regulates conveyor speeds—even to fractions of an inch per minute. Example: On this Mold Conveyor, used in a Michigan foundry, a REEVES Variable Speed Transmission varies travel speed of parts and coordinates the work of men and machinery throughout the foundry.



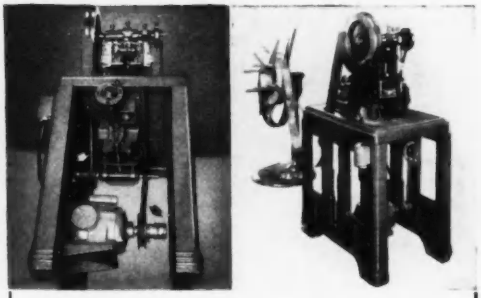
3 REEVES synchronizes parts of one machine, or machines in series. Example: To insure perfect control of shrinkage of cloth, of whatever fabric is being "preset", with this new Van Vlaanderen Boil-Off Machine, five REEVES Speed Control units are used. A REEVES Motodrive varies the speed through the entire range, as desired, and four small REEVES Transmissions drive the four pairs of drums.



4 REEVES accurately controls heating, baking, drying, cooling or chilling time. Example: A REEVES Variable Speed Transmission, driving through a gear reducer, gives the exact rate of speed required for annealing various kinds and thicknesses of metal, with this bright annealing furnace; pulls the metal strip through the furnace, and then actuates the coiling of metal strip.



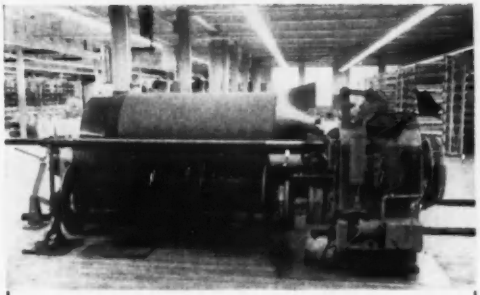
6 REEVES compensates instantly for variances in weight, liquid level, temperature, etc. Example: To accurately maintain uniform boiler pressure of this stoker, REEVES Variable Speed Transmission automatically increases or decreases speed of the grate travel in response to the steam demand.



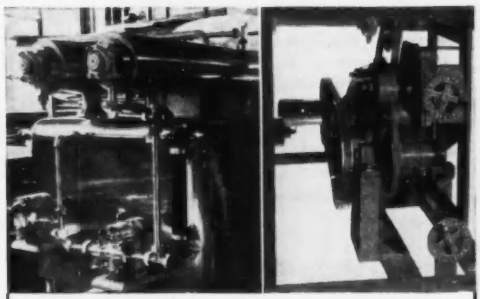
7 REEVES matches variances in number or individual skills of operators. Example: On this automatic stamping and punching press, using a 1740 rpm motor, two REEVES Vari-Speed Jrs. accurately regulate speed of production . . . from 9,000 to 36,000 pieces per hour, according to size, shape and kind of part, and ability of the operator.

8 WAYS REEVES Speed Control helps machine designers hurdle the eight ball

Designers and builders of more than 2,100 different makes of modern machines have already licked their speed control problems by including REEVES Variable Speed Drives as standard equipment. You can do the same. The complete REEVES line of variable speed equipment, built around three basic units, offers you the widest selection of designs, sizes, capacities, and speed ratios—with manual, push-button or completely automatic controls. And REEVES internal operating parts also are available for easy incorporation within the framework of machines. A widely experienced REEVES Speed Control specialist will be glad to recommend the REEVES units best suited to your particular needs. Write for name of the REEVES representative nearest you and for catalog K23-3N.



5 REEVES maintains uniform peripheral speed, or tension, of winding and unwinding operations, on increasing or decreasing diameters. Example: On this high-speed textile beamer, a REEVES Variable Speed Transmission, with hydraulic automatic control, automatically maintains uniform tension and constant winding speed to assure uniform yarn texture.



8 REEVES compensates for changes in consistency, density, or viscosity of materials in process. Example: On this marshmallow blending machine, two REEVES Vari-Speed Motor Pulleys (right) assure a uniform product by regulating speed of pumps which control the amount of air and ingredients entering the blending chambers.

The Three Basic Reeves Speed Control Units

VARIABLE SPEED TRANSMISSION for providing infinite, accurate speed flexibility over a wide range—2:1 to 16:1. Sizes—fractional to 87 hp.

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Reeves Speed Control

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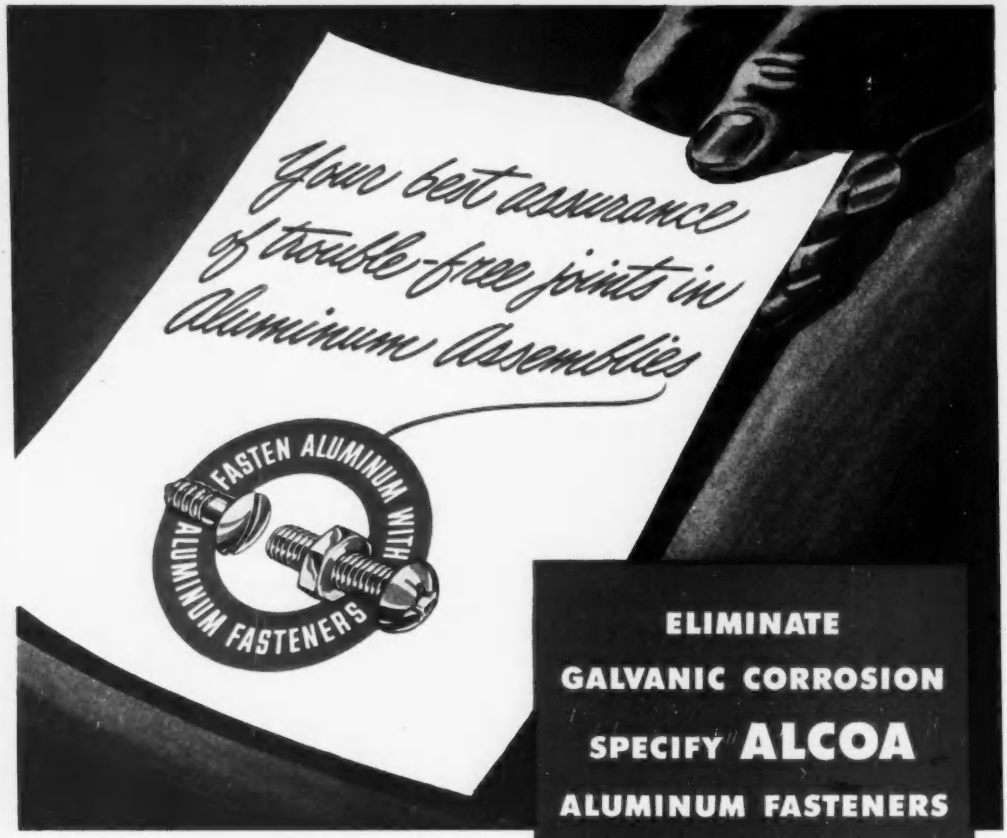

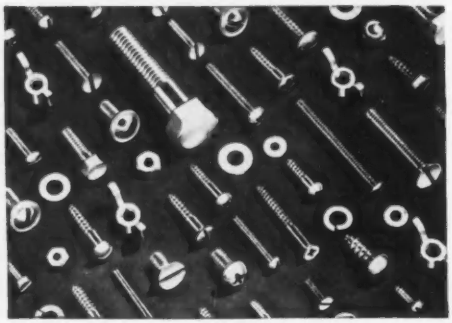

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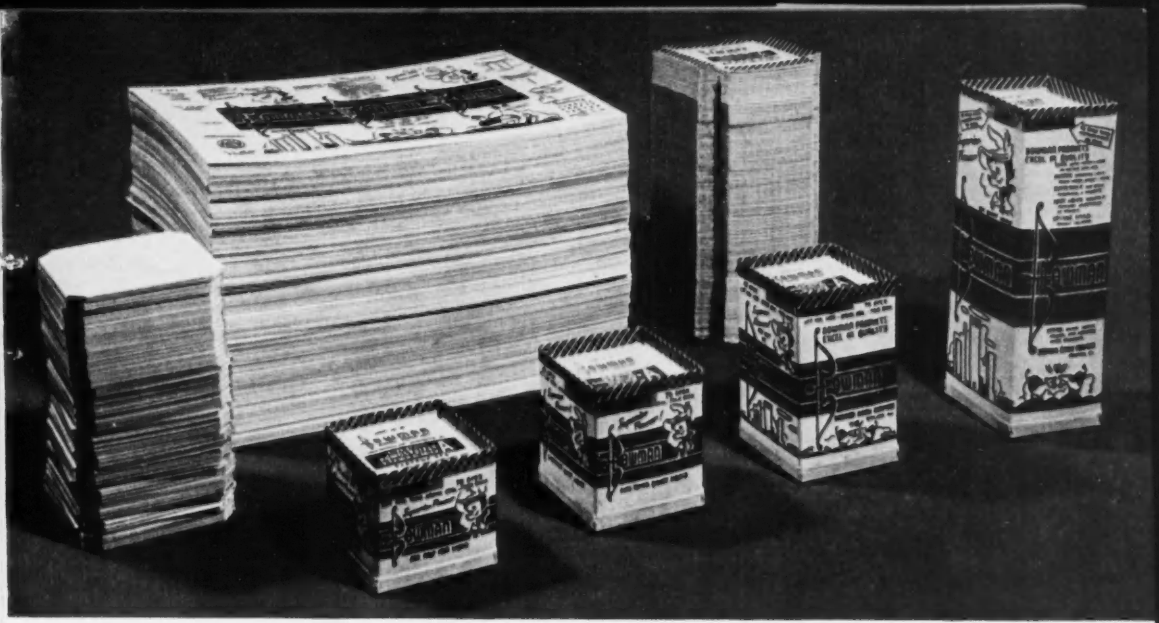

STEP UP EFFICIENCY... SLICE COSTS

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Save up to 90% in shipping space! Strong heat seal of VINYLITE Resin coatings makes it possible to ship milk containers in flat sheets and to sterilize, fill, close and date in one automatic operation. This Sealking Carton made by Sealright Co., Inc.

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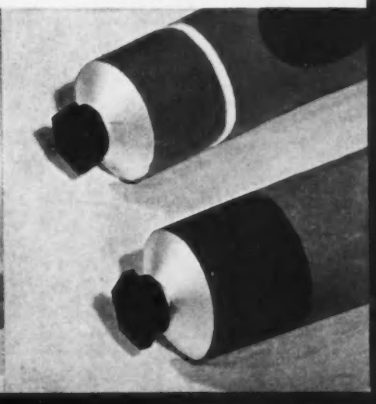
Eliminate costly manufacturing procedures! Rugged, flexible VINYLITE Resin coatings are applied on flat steel—white on one side, for the lining, colored on the other—before this container is formed. Finishing materials by Bradley and Vrooman Co.

One coat does the job of two! Chemical resistant VINYLITE Resin coatings do not flake from tubes—even those containing lather shaving cream . . . save drying time . . . increase production capacity. By John L. Armitage & Co.



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• New beauty, convenience, economy has been made possible through the use of plastics and metal and plastic combinations. The modern automobile has demonstrated this great potential. And the broad scope of the varied applications is being repeated again and again throughout industry.

Here under one roof at Auto-Lite's great Bay Manufacturing Division in Bay City are the technical skills and production capacity for a new art rendered in plastics. The artistic skill of Auto-Lite's Art and Style Division is available on matters of design and development.

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Yes, among the many economies and advantages of Veeder-Root Counters, you can count on them to boost workers' morale and keep it at high level. That's one of the reasons why management and plant operating heads are coming more and more to specify production machines and equipment featuring *built-in* Veeder-Root Counters. And *that's* why it's smart salesmanship to build Veeder-Root Counters into *your* product . . . to bring a new utility to your customers. But how to do it? That's for us to show you. Just write.

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No. 1239

HIGH-SPEED PREDETERMINING COUNTER

is furnished with electrical contact or mechanical knock-off lever. Speeds up to 2500 counts per minute. This is one of scores of V-R Standard Counters. Write for 8-page Condensed Catalog to Veeder-Root Incorporated, Hartford 2, Conn.

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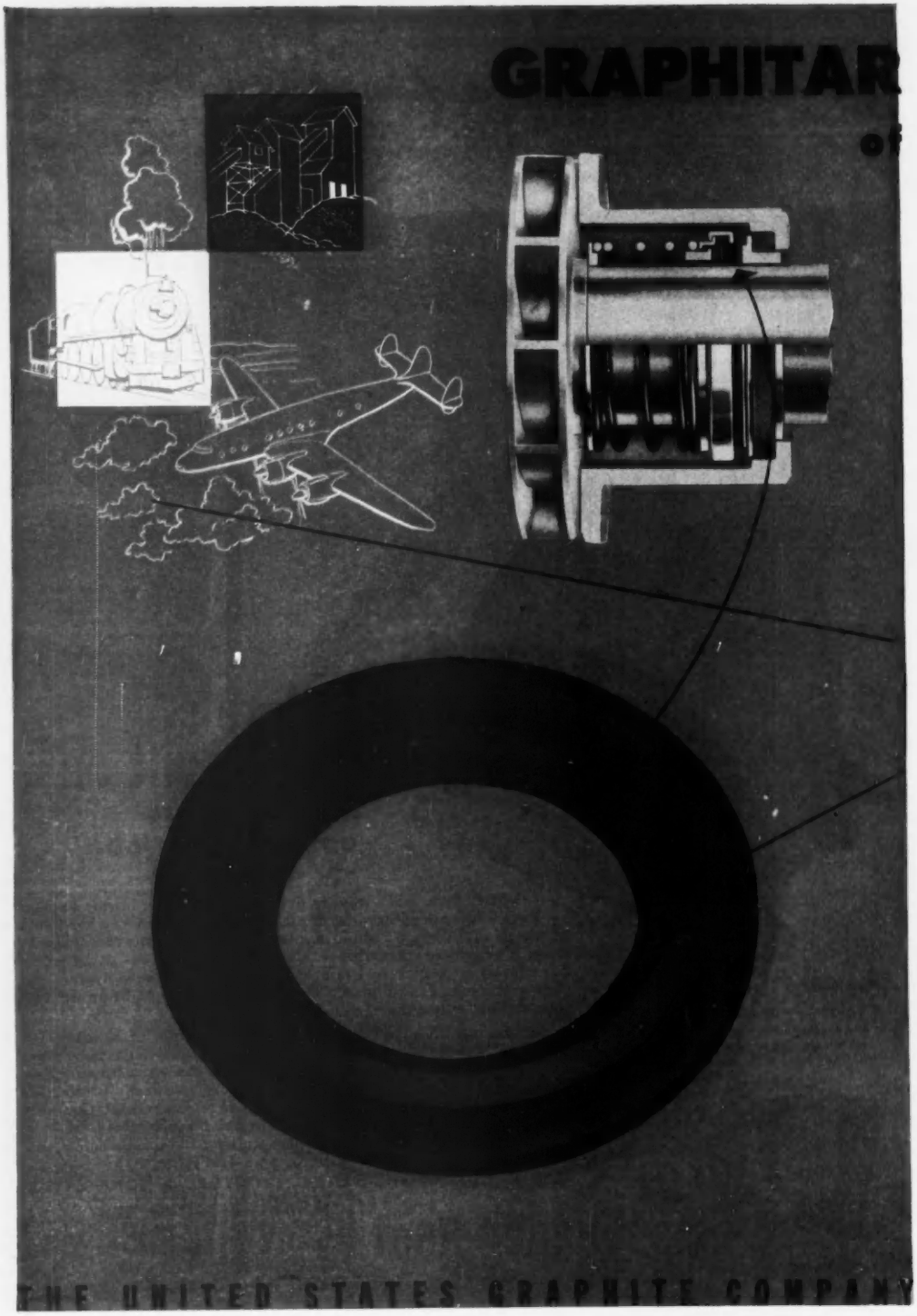
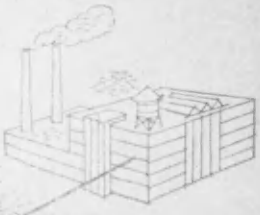

GRAPHITAR
THE UNITED STATES GRAPHITE COMPANY

assures successful operation high speed liquid seals

Gits Specifies Graphitar for Oilseal Assembly To Solve High Speed Sealing Problem



● Keeping the lubricating oil separated from liquids being pumped at high speeds and pressures was a problem for the Gits Brothers Manufacturing Co. of Chicago, until they specified Graphitar for the nose piece of their oil-seal assembly for pump manufacturers. Now the Graphitar seal helps *keep pumps operating smoothly* despite operating conditions of 150 psi pressure, 4000 RPM and 150°F. temperatures.

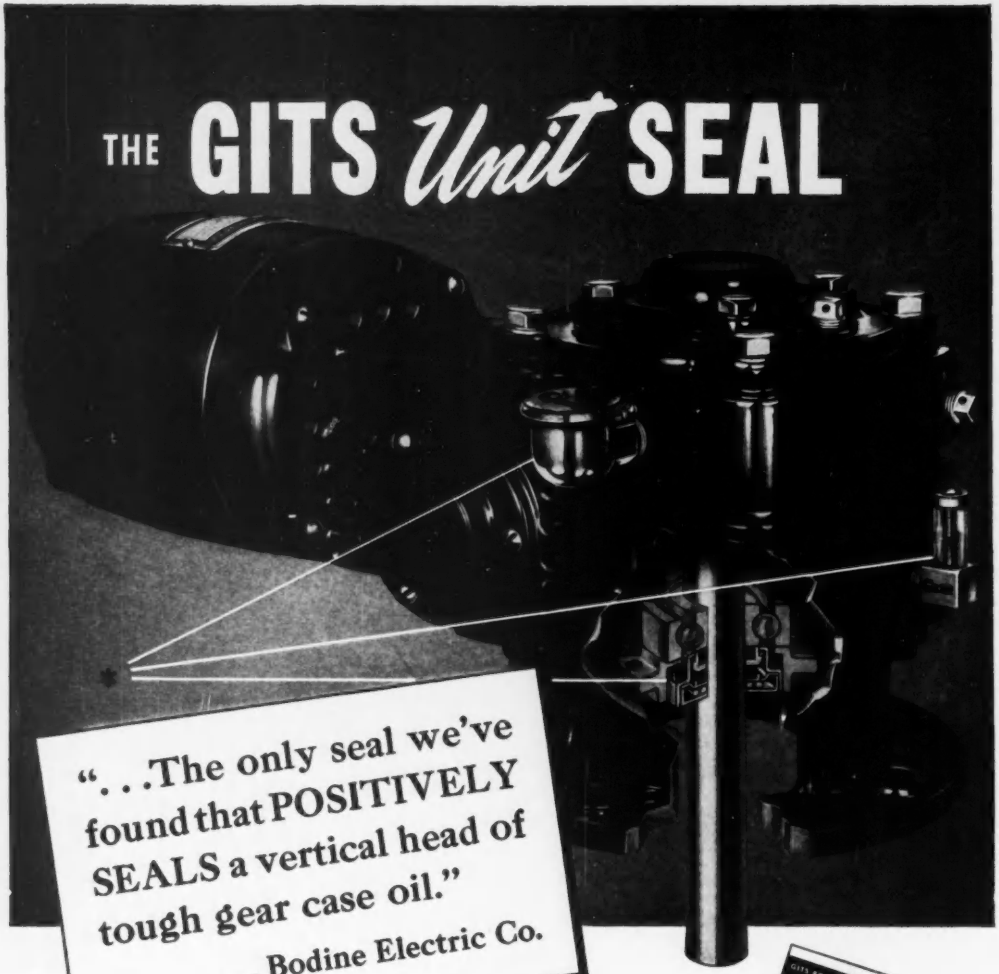
● This is another typically difficult sealing problem that Graphitar is solving in industry today. Graphitar seals seat themselves and form a drop-tight seal under conditions that many conventional seals cannot tolerate. Graphitar *does not warp or distort under heat*, it is corrosion resistant and mechanically strong. Graphitar is a carbon-graphite product that is self-lubricating and extremely light. It can be ground to tolerances as *close as .0005" in small sizes*. Our engineers may be able to suggest Graphitar applications that will improve the efficiency of your products. Send us your prints for recommendations without obligation.

Ask for your copy of the Graphitar catalog.

GRAPHITAR

DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN

THE GITS *Unit* SEAL



"...The only seal we've found that POSITIVELY SEALS a vertical head of tough gear case oil."

...Bodine Electric Co.

That's why Bodine Electric Company engineers chose the Gits Unit Seal for the Bodine "Group 4" worm gear reducer (shown here). Gits engineers then *applied* the Unit Seal without causing any redesign of the reducer.

Gits Seals can solve *your* shaft sealing problems, too —effectively and economically. Send us your shaft sealing problems on *any* type of equipment, for prompt recommendations (no obligation).

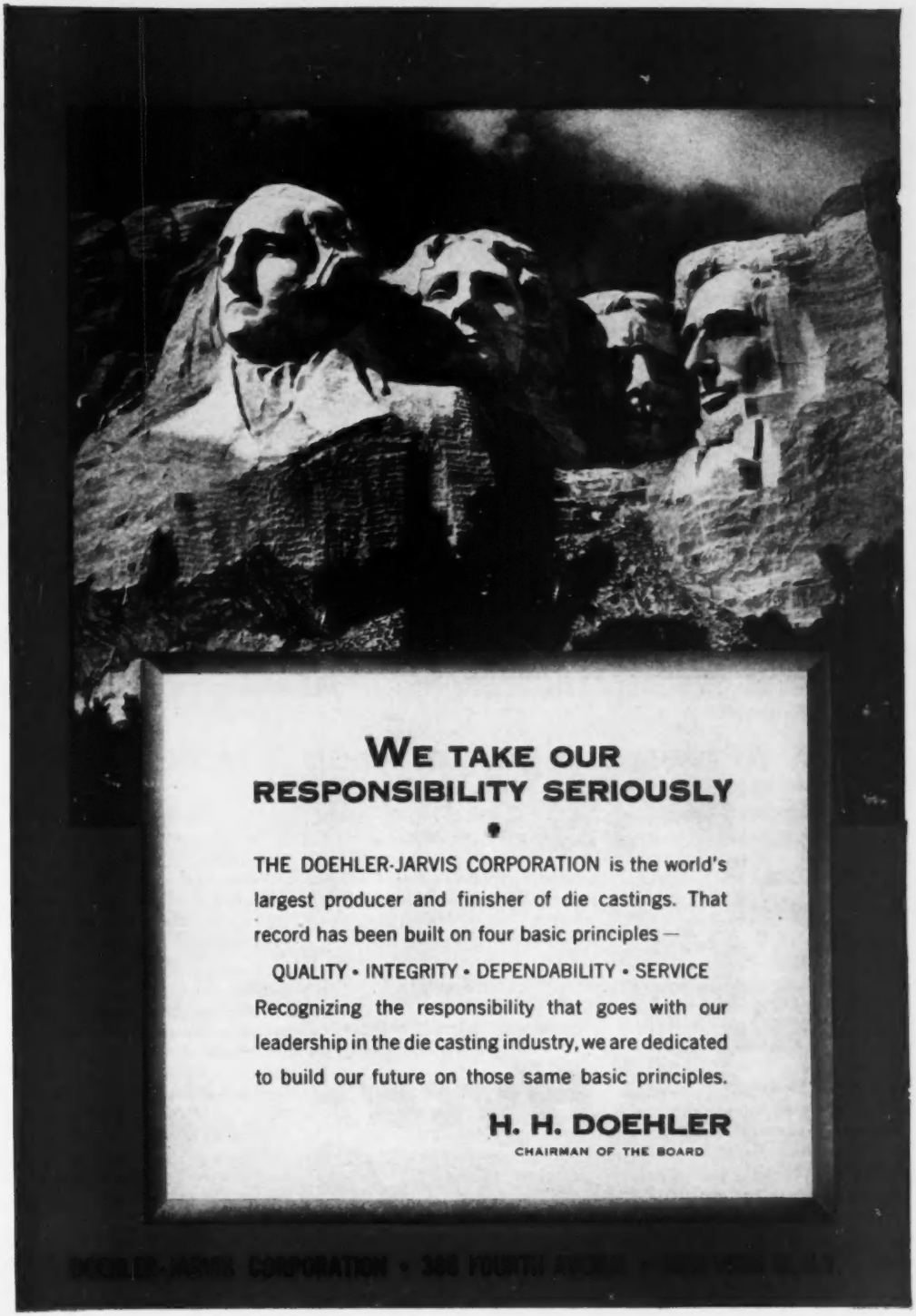
Write Today

for informative, detailed booklet on the Gits line of shaft seals—complete with diagrams and illustrations of various applications.

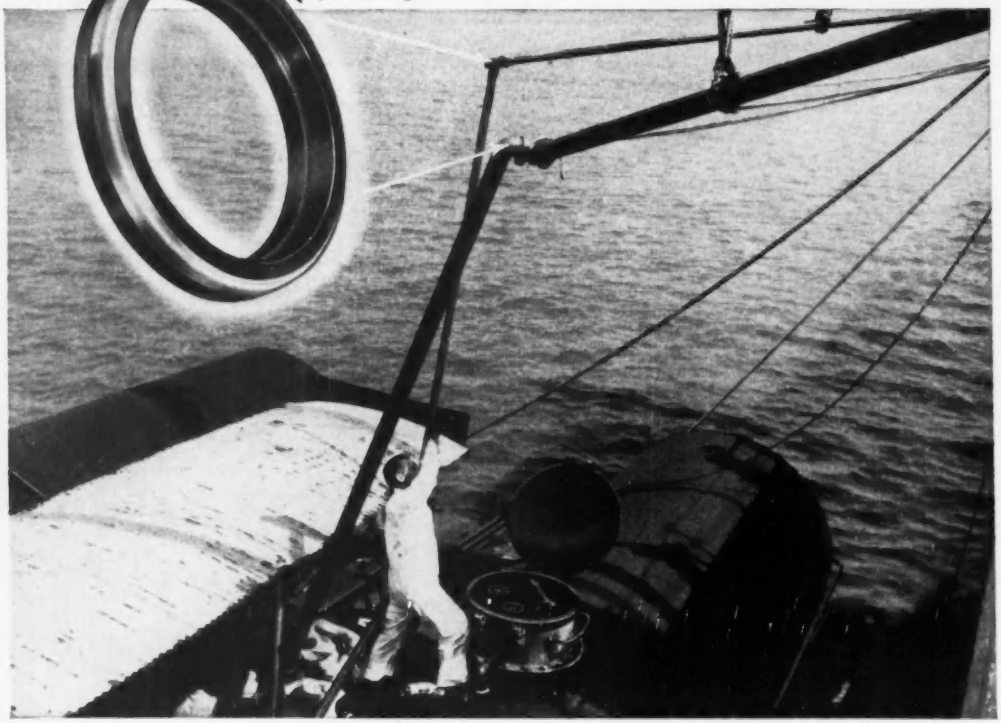
GITS BROS. MFG. CO.

1838 S. Kilbourn Ave. • Chicago 23, Illinois

* Note the Gits "Style FG" Oil Gauge and the Gits "Style KV" Oil Cup. Gits oils it, seals it, gauges it!


WE TAKE OUR
RESPONSIBILITY SERIOUSLY
THE DOEHLER-JARVIS CORPORATION is the world's largest producer and finisher of die castings. That record has been built on four basic principles —
QUALITY • INTEGRITY • DEPENDABILITY • SERVICE
Recognizing the responsibility that goes with our leadership in the die casting industry, we are dedicated to build our future on those same basic principles.
H. H. DOEHLER
CHAIRMAN OF THE BOARD

◀ *Hycar Packing Unit*



Packing unit molded from Hycar by Kirkhill Rubber Co., Los Angeles, California

Swivel joints made by Chiksan Co., Brea, California

How to twist a pipe, yet keep it leak-proof

TRANSFERRING liquified petroleum gas from tank cars to ships used to be a tough job. Discharge pipes couldn't be twisted or turned to hit the right spot, at just the right angle.

But an easy way to do the job was found after two tricky problems were licked. One problem went by the boards when the Chiksan Ball Bearing Swivel Joint was developed. This unique joint makes it possible to twist and turn pipe to just about any angle. The other problem—leak-proofing the joint—was solved with a packing unit made with Hycar American rubber.

The Hycar Packing Unit, a flexible seal between the metal parts, exhibits minimum volume change under service conditions. It effectively stops leakage of gas or liquid flowing from one section to another. Swivel joints are used successfully wherever gases or liquids are transferred or transported—such as refineries, chemical plants, dairies, food processing plants, bottling works and canneries.

Hycar was chosen for the leak-proofing job because it has such a wide range of qualities. It is resistant to oil and gas, abrasion, and does not flow even under extreme pressures. Hycar compounds can be varied from extremely soft to bone hard, and made in many colors.

Hycar may be just what you're looking for to answer a problem . . . to make better, more saleable products. For Hycar is used as a base material . . . as a plasticizer for vinyl resins . . . as a modifier for phenolics . . . as an adhesive base . . . as a latex for coating or impregnating. Send for complete information. Just write Dept. HJ-11, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

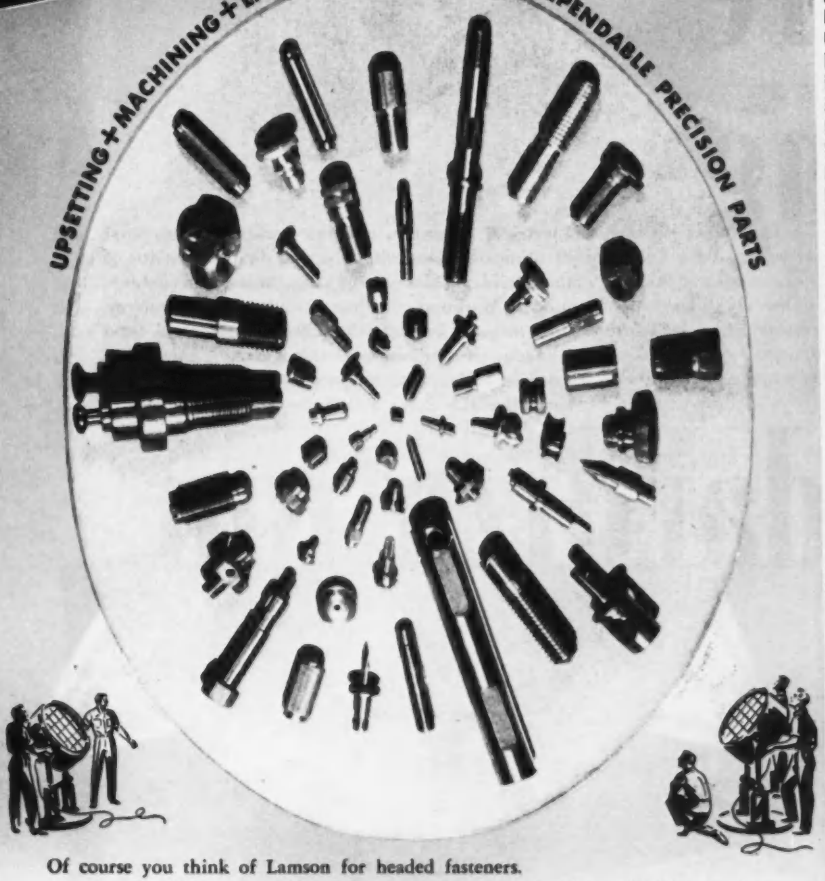
Hycar
Reg. U.S. Pat. Off.
American Rubber

B. F. Goodrich Chemical Company
A DIVISION OF THE B. F. GOODRICH COMPANY

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers

The Spotlight's on "Specials" BY LAMSON!

UPSETTING + MACHINING + LAMSON "KNOW HOW" = DEPENDABLE PRECISION PARTS



Of course you think of Lamson for headed fasteners.

But did you know that Lamson produces precision Screw Machine Products for many of the country's best known, "blue ribbon" manufacturers?

Within this one organization are modern facilities for hot and cold heading, machining, grinding, broaching, bending, flattening, punching, drilling, heat-treating and plating.

Add to these facilities Lamson's unsurpassed "know how" and you'll understand why it's wise to check with Lamson *first* for small parts production . . . Screw Machine, Upset or a combination.

THE LAMSON & SESSIONS COMPANY

General Offices: 1971 West 85th Street, Cleveland 2, Ohio

Plants at Cleveland and Kent, Ohio • Birmingham • Chicago

Lamson & Sessions

"One Dependable Source for All Fastener Needs"

SEMS	LOCK NUTS	NUTS	STUDS
STOVE BOLTS	LAG BOLTS	WASHERS	RIVETS
TAPPING SCREWS	ROPE CLIPS	SET SCREWS	PLOW BOLTS
"1035" CAP SCREWS	MACHINE BOLTS	CARRIAGE BOLTS	COTTER PINS

WANT MORE INFORMATION on any of these fasteners? *CHECK*—and *CLIP* this strip.

LAMSON LOCK NUTS: Economical, vibration-proof. Can be re-used repeatedly.

SEMS: Tapping and Machine Screws with Lockwashers attached.

COTTER PINS: Steel, Brass, Aluminum and Stainless Steel.

"BENT" BOLTS: Including U Bolts, Eye Bolts, Hook Bolts, etc.

LOK-THREAD STUDS: Thread locks and seals in standard tapped holes.

Wire Rope Clips: Hi-Center saddles, extra-strength U Bolts.

PLASTIC INSERTS: To your specifications . . . in production quantities.

AIRCRAFT FASTENERS: AN Bolts, Nuts, Screws, Studs and Cotters.

"1035" CAP SCREWS: Hi-Tensile heat-treated steel.

—CUT ALONG THIS LINE—

The Lamson & Sessions Company
1971 W. 85th St., Cleveland 2, Ohio

NAME

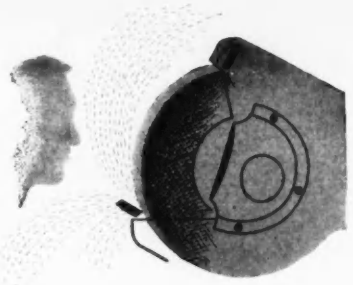
POSITION

COMPANY

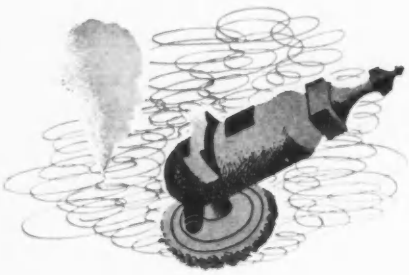
STREET

CITY ZONE STATE

they're strong for standardization

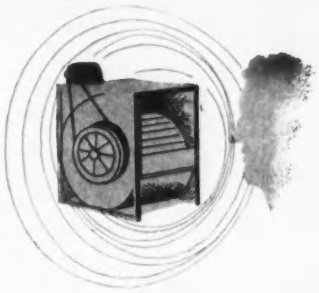


Electrical Engineer, machine tool company, says: "I think designers will save time in the long run if they decide, at the start of a job, to use standard motors. We'll eliminate exhaustive engineering tests we used to make on fractionals. With horsepower, service factor, breakdown torque, and starting current all rated on a clear-cut, uniform basis we'll know *in advance* that the motor will do the job."



Chief engineer, portable tool plant, says: "I simplify design when I specify series-motor parts with NEMA standard dimensions for our portable tools. By designing tool housings to take parts conforming to these standards, I simplify case construction, obtain interchangeable motor design, and lower overall costs."

Vice-President, washing machine company, says: "The use of *standard* washing machine motors helps our dealers to give dependable service. With standard motors, the service man can take full advantage of the motor manufacturer's motor-exchange and repair-service plans—take the headaches, and delays, out of motor repairs or replacement. He can be sure that the motor he puts back on the job will perform as it should."



President, electric blower corporation, says: "The big thing about the new fractional-hp motor standardization plan, to me is that we stand a better chance of getting 'off-the-shelf' delivery of motors when they are a big-production item, instead of a special. Also, we eliminate special jigs and fixtures, and the need for making universal mounting bases and adapter plates."

Head of oil burner firm says: "Standardization of motors and parts is most important to our company. Our burners can be made in several sizes and types without changing the motor size or application, even when making improvements and new models. Standardization means lower production and inventory costs for oil burner manufacturer and distributor or dealer."

They use General Electric Standardized FRACTIONAL HORSEPOWER Motors

WANT TO SEE whether a switch to standardized General Electric fractional-hp motors will pay off for you? Our engineers will be glad to give you the unvarnished facts. Just drop us a line giving the size, type and special characteristics of the motors you are now using. For general information about fractional-hp motor standards write for Bulletin GES-3565. Apparatus Department, General Electric Company, Schenectady 5, N. Y.

GENERAL ELECTRIC

705-99

Tru-Spot Flashlight—*made from Kaiser Aluminum* by Ekco Products Company, 1949 North Cicero Ave., Chicago, 39. The one-piece seamless case is 6⅜ inches long, 1½ inches in diameter, with a flared top 2 inches in diameter.

Drawn from a blank...with no annealing!

In eight easy stages the Tru-Spot Flashlight case is drawn from a blank of Kaiser Aluminum—*automatically*—without a single anneal!

Consistent high quality and workability of Kaiser Aluminum make this operation successful and economical—and give Ekco profitable advantages like these:

Lower manufacturing costs—due to elimination of many steps in handling and fabricating. Low cost tooling set-up—because Ekco uses exactly the same equipment formerly used for a more expensive metal!

Scrap loss is cut. Plating is unnecessary because a bright, lasting finish is produced merely by buffing!

And the sturdy seamless case has unmatched sales appeal!

No matter what fabricating method *you* use, chances are you can profit with Kaiser Aluminum—the *versatile* metal that combines strength, durability, lightness, workability. Call any Permanente Products' sales office for more information.

Permanente Metals

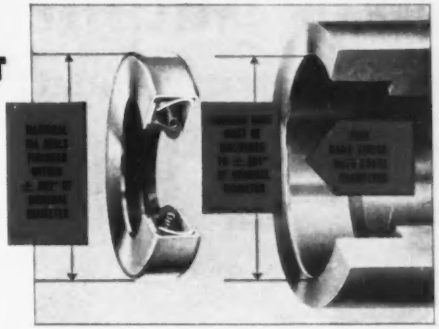
PRODUCER OF

Kaiser Aluminum

SOLD BY PERMANENTE PRODUCTS COMPANY, KAISER BUILDING, OAKLAND 12, CALIFORNIA . . . OFFICES IN: Atlanta • Boston • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Kansas City • Los Angeles • Milwaukee • Minneapolis • New York • Oakland • Philadelphia • Portland, Ore. • Rochester, N.Y. • Seattle • Spokane • St. Louis • Wichita EXPORT OFFICE, OAKLAND, CALIFORNIA • WAREHOUSE DISTRIBUTORS IN PRINCIPAL CITIES

NATIONAL OIL SEAL LOGBOOK

CORRECT PRESS-FIT NECESSARY FOR EFFICIENT OIL RETENTION



It is obvious that a metal-encased oil seal, no matter how well designed and carefully manufactured, will not perform efficiently unless installed in an accurately machined bore. Yet, many times it is true that proper care is not exercised during course of production to prepare the housing bore to accurate press-fit tolerance.

To achieve a good seal at the O.D. of a metal-encased oil seal, it is necessary to machine the bore to ± .001" of the nominal oil seal diameter. This bore should also be chamfered at outer edge to prevent shearing of the oil seal case. The finish of the machining should be as fine as practicable so as to eliminate the possibility of scratching the oil seal case as it is pressed into the housing. Even small scratches can result in bad leakage around the outer periphery. In production, National metal-encased oil seals are gauged to within ± .002", which will provide an effective closure in the properly machined bore. In extreme cases special adhesives are sometimes employed to insure closure between oil seal and housing bore.

NATIONAL RUBBER-COVERED SEALS REQUIRE LESS CRITICAL BORE

Section of typical National rubber-covered oil seal. Note thin rubber section at O.D. and rigid steel truss frame.

Newly developed National rubber-covered oil seals may make possible important savings in machining and assembling costs. They are soft and flexible enough to form a perfect closure between the O.D. of seal and the housing bore, even allowing for minor flaws in the finish. However, these seals must be built upon a rigid steel truss frame with a minimum of rubber on the O.D. so as to maintain accurate O.D. dimension and fit under all operating conditions.

National engineers are anxious to help you with any oil or fluid retention problems. For further information contact nearest office or write direct.

NATIONAL OIL AND FLUID SEALS

NATIONAL MOTOR BEARING CO., INC.

General Offices: Redwood City, Calif.
Plants: Redwood City and Los Angeles, Calif.; Van Wert, Ohio

1949

CALL IN A NATIONAL ENGINEER FOR RECOMMENDATIONS

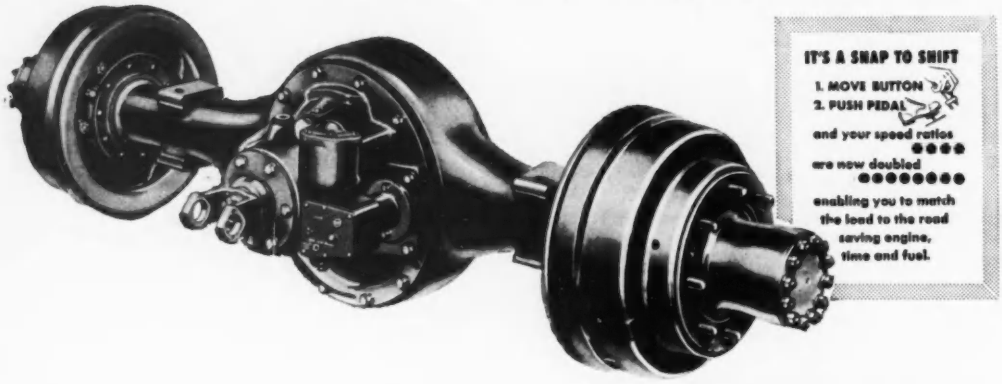
BUFFALO: 56 Arlington Place, Grant 2280.
CHICAGO: Room 2014 Field Building, Central 6-8663.
CLEVELAND: 210 Heights Rockefeller Bldg., Yellowstone 2720.
DALLAS: 30½ Highland Park Village, Justin 8-8453.
DETROIT: Room 1026 Fisher Building, Trinity 1-6363.
HOUSTON: 6731 Harrisburg Boulevard, Wayside 3-1246.
LOS ANGELES: 2244 East 37th Street, Kimball 6384.
MILWAUKEE: 647 West Virginia St., Marquette 8-8986.
NEW YORK CITY: 122 East 42nd Street, Lexington 2-8260.
PHILADELPHIA: 401 North Broad Street, Bell-Walnut 2-6997.
REDWOOD CITY, CALIF.: Broadway and National, Emerson 6-3861.
WEST SPRINGFIELD, MASS.: 1025 Elm Street, Springfield 2-1881.
EAST SYRACUSE, N. Y.: 226 Roby Avenue, East Syracuse 366.
WICHITA: 340 North St. Francis Ave., Wichita 2-6971.

Reprints from this or other Logbook pages are available for your files. Request them from our Redwood City, California, office

MALLORY

Takes Nothing For Granted...

and the Eaton Manufacturing Company is Pleased!

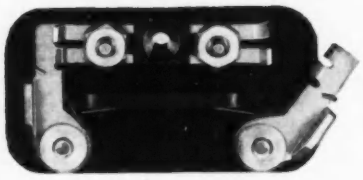


The popular Eaton 2-speed truck axle is controlled by a little button. The driver moves it and the truck's speed ratios are doubled in number. Crushing loads start with ease. Rough uphill hauls in quarries or in construction jobs are a cinch. And owners save wear, tear and money on their truck equipment!

When planning the electric shift, the Eaton Company submitted specifications for the required switch to Mallory.

Mallory engineers looked at the design submitted to them with inquisitive eyes. Backed by the greatest pool of experience and skill in the field, Mallory engineers suggested manufacturing methods that resulted in appreciable production cost savings at no sacrifice in performance.

If you are in the throes of a design problem calling for precision electronic parts—switches, controls or resistors —it will pay you to call in Mallory engineers now. Their record in the industry is famous. Because they take nothing for granted, you'll be sure of getting the finest design at the best possible price.



Clean-cut, simple, long wearing and trouble-free, this Mallory-made switch used to activate the Eaton 2-speed axle is typical of the kind of product that has made Mallory "switch headquarters" for American industry.

Precision Electronic Parts—Switches, Controls, Resistors

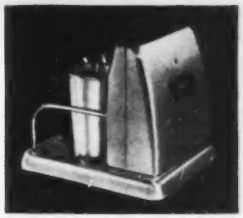
P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

SERVING INDUSTRY WITH

Capacitors — Rectifiers
Contacts — Switches
Controls — Vibrators
Power Supplies
Resistance Welding Materials

AN IDEA DEVELOPED INTO A *finished product* BY GEUDER, PAESCHKE & FREY CO.

This Stainless Steel Campbell "Counter Kitchen" came to us just as an idea. It was developed by G. P. & F. Models were made in our experimental laboratory, construction perfected by our engineering staff, and the final product completely fabricated, assembled, wired for automatic electric operation, and polished to a satin finish . . . all as a part of G. P. & F. complete service.



This is just another example of GEUDER, PAESCHKE & FREY CO. OVERALL FACILITIES

If you have "just an idea," or a need, G. P. & F. is ready to help you develop it. If you have a product that requires improvement or redesigning to add beauty and lower production costs for a "buyer's market"... if your own production lines are inadequate and you hesitate to add costly equipment, investigate G. P. & F. proved complete service.

Prominent companies, both large and small, are taking advantage of G. P. & F. service in the production of sheet steel and aluminum items ranging from automotive and farm equipment parts to enameled washing machine tubs and stainless steel fruit juicers.

ENGINEERING — DESIGNING
STAMPING — DRAWING — FORMING
ALL TYPES OF WELDING
TINNING — GALVANIZING — LEAD COATING
VITREOUS ENAMELING — SPRAY PAINTING

Write Contract Division

G.P.&F.
CONTRACT DIVISION
MILWAUKEE

Our engineering, metal working and finishing specialists will gladly work with you.

GEUDER, PAESCHKE & FREY CO., 1585 W. ST. PAUL AVE., MILWAUKEE 3, WISCONSIN

Where solutions are corrosive, Stevens Automatic Plating Machines use *Stainless-Clad Steel Tanks*

Mild acid condition exists in bright dipping and subsequent treatments so Frederic B Stevens, Inc., of Detroit, are using Lukens-Stainless-Clad Steel for these tanks in their Model "C" Full Automatic Small Parts Plating Machines.

Tailored to meet your exact requirements—Stevens Plating Machines take into account every solution you'll be handling in every step of your process. Therefore, Stevens uses ordinary steel, rubber lined, and type 316 Stainless-Clad Steel tanks side by side in one machine.

Because the cladding in Lukens Clad Steels is uniform and permanently bonded to its backing plate, tanks made of this material behave as though they were *solid* corrosion-resistant metal. Plate thickness, necessary for structural strength and stiffness, is obtained with typical *clad* steel savings.

Lukens makes Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels, enabling manufacturers to meet various corrosive and erosive conditions. Claddings 10% or 20% of total plate thickness suit most applications. Ask your supplier about the use of these money-saving, long-lived materials.

Bulletin 449 contains further information on Lukens Clad Steels. For a copy, write Lukens Steel Company, 405 Lukens Building, Coatesville, Penna.

CLAD METAL STEEL

LUKENS

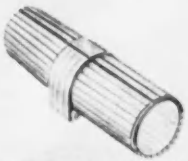
Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

MOLDED IN PLASTICS BY GENERAL ELECTRIC

"Fragrance Bar" and "Cinderella Slipper" display packages molded by General Electric for Coty, Inc.

LARGE VOLUME JOBS! G. E. is ideally equipped to mold large quantity jobs—like this soap dispenser for the Voorhis-Tiebout Co.



LOW SELLING PRICE! Using G-E plastics for a paper cup dispenser enables the Dixie Cup Company to offer a low-cost home unit.

PLASTICS FOR INSULATION! This contact shaft, molded by G. E., furnishes its own insulation, retains dimensional stability.

Plastics

How G-E Plastics Can HELP SELL YOUR PRODUCTS

Here's an excellent example of how G-E plastics help to sell products. These eye-catching plastics packages —the slipper-shaped perfume holder (acrylic) and the toilet water "Fragrance Bar" (polystyrene—were both molded by General Electric for Coty, Inc. Each unit combines sales appeal with ready-to-work utility . . . makes an attractive display in the store or on a dressing table.

This kind of imaginative packaging provides the added sales life that moves merchandise. But whether you can use plastics packages, or molded plastics parts or products, you can depend on General Electric plastics service for low cost and high quality.

One of the world's largest plastics molders, G. E. is ideally equipped for *large volume* production. WRITE US FOR MORE INFORMATION on how this service can work for *you*. Or contact your nearest G-E sales office. Address: Plastics Division, Chemical Department, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

GENERAL ELECTRIC

CD49-A47

General Electric plastics factories are located in Coshocton, Ohio, Decatur, Ill., Taunton and Pittsfield, Mass.

EATON PERMANENT MOLD GRAY IRON CASTINGS *for Hydraulic Applications*

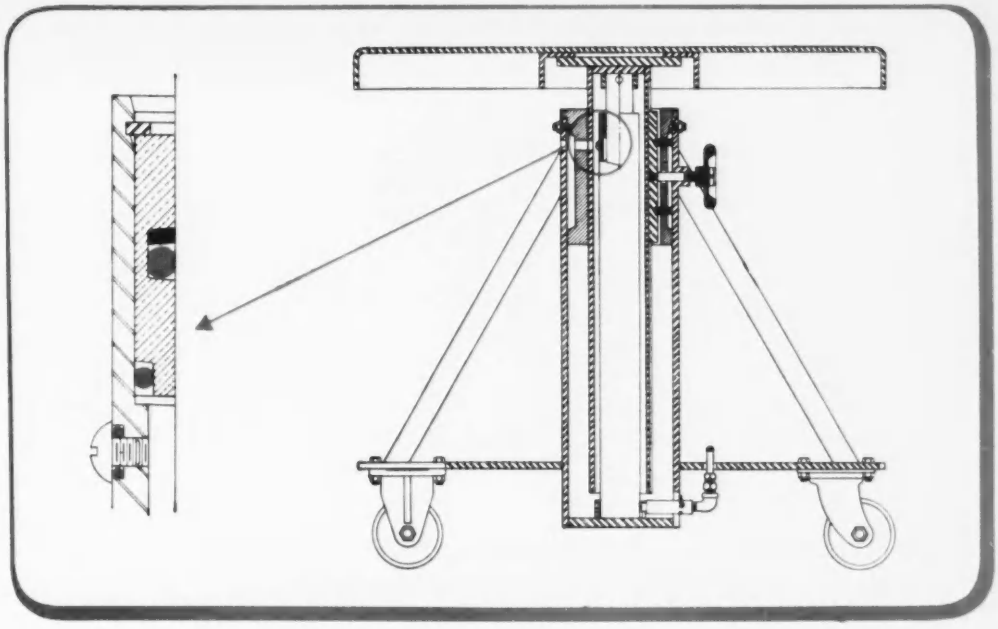
NEW BOOKLET. Send for your copy of the new, illustrated booklet, "The Eaton Permanent Mold Process," which describes the Eaton Permanent Mold machine, and the Permanent Mold Process. It also includes pointers on designing Gray Iron Castings to be produced by the Eaton Permanent Mold Process.

THE dense, non-porous structure of Eaton Permanent Mold Gray Iron Castings insures freedom from leakage under pressure. In addition, this material machines to the high mirror-like finish required on a majority of parts for hydraulic applications. Proper annealing insures that castings will hold size and not distort after machining. Free machinability makes for production speed and holds machining cost to a minimum.

Eaton Foundry Division engineers will be glad to discuss the application of Eaton Permanent Mold Gray Iron Castings to your product.

THE EATON PERMANENT MOLD MACHINE IS A SYMBOL OF THE QUALITY OF GRAY IRON CASTINGS PRODUCED BY THE PERMANENT MOLD PROCESS.

EATON
MANUFACTURING COMPANY
FOUNDRY DIVISION
9771 French Road • Detroit 13, Michigan



25% Saving With Linear "O" Rings*

Another LINEAR achievement! "O" Rings used in this Lyon-Raymond Portable Hydraulic Elevating Table simplified design and effected savings of nearly 25%. After a test of 50,000 operating cycles with pressures varying from 900 p.s.i. to 2,000 p.s.i., the "O" Rings showed little wear and were effectively holding a fluid-tight seal.

Whether you require a seal for a hydraulic design or for a special service, LINEAR precision moulded packings will serve you well.

In addition to a long list of natural or synthetic rubber compounds adaptable to a wide range of temperatures, gases and liquids, LINEAR is successfully moulding "O", "V", "U" or other shapes of Kel-F, Teflon and Silicone for special applications. These special materials are suitable for seals for a wide temperature range from minus 320° F. to plus 400° F. against concentrated sulfuric, hydrofluoric, hydrochloric and other vigorous oxidizing materials.

For your individual packing design or application, CALL LINEAR.

*The use of "O" Rings in certain packing structures is covered by Christensen Pat. No. 2,180,795 under which we have paid the royalty for the installation of our rings in these structures so that the royalty is included in the purchase price of the "O" Ring.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK STREET, PHILADELPHIA 35, PA.

Sometimes it costs less to use Steel that costs more!

Here, U·S·S COR-TEN used cuts weight 18%

*** The bigger the tank the bigger the saving**

In the 42" x 10' Stonesteel tanks under construction above, the use of COR-TEN reduces weight 553 lb., saves $5.00 on material cost. When these lighter COR-TEN tanks were shipped to a housing development in Norfolk, Va., freight charges were $9.84 less, bringing the total savings per tank to $14.84.

U·S·S

in place of carbon steel

cuts material cost 10.8%

cuts shipping cost 16%

During the past 12 years, U·S·S Cor-Ten—the pioneer high strength steel—has earned a world-wide reputation for reducing costs by reducing weight in freight cars, buses, trucks and other mobile equipment. That's exactly what Cor-Ten was developed for, so we were not surprised.

But here is the story of a money-saving application, far outside the transportation field, that aptly illustrates how stationary equipment of many kinds can be built advantageously of U·S·S Cor-Ten in place of carbon steel—not only to improve the product but to reduce its cost.

SEVERAL years ago the Cemline Corporation of Cheswick, Pa., developed a hot water storage tank designed to prolong life even in those areas where water supplies are unusually corrosive. A special hydraulic cement lining that prevents corrosion by eliminating any corrosive water-to-metal contact did the trick. But in solving the corrosion problem the cement lining created another. Its substantial weight when added to the weight of the heavy carbon steel shell resulted in a unit that was unwieldy to handle and difficult and costly to install.

A lighter tank was definitely called for. This need was emphasized with every increase in freight rates, and as more and more tanks were shipped to distant markets. The question was, how to reduce weight and still meet high strength requirements. Cemline engineers found the answer in U·S·S Cor-Ten.

Due to the protective lining, interior corrosion could be disregarded, so they were able to take full advantage of U·S·S Cor-Ten's high yield point (50,000 psi.) and to use it in gages 40% lighter than the carbon steel gages previously required. This 40% reduction in cylinder weight reduced the total tank weight 18%.

These weight savings resulted in cost savings all along the line. Cost of the steel per cylinder was 10.8% less (because the weight saved more than offsets Cor-Ten's slightly higher cost). The lighter tanks were handled with less trouble and less expense. And, freight charges on every shipment—on steel from the mill, on the tanks to the customer—were reduced almost 16%.

To show what this means in actual dollars and cents savings, take the case of the 45-gallon Stonesteel tank (shown at right) produced by the thousands for residential use. Replacing the carbon steel shell, .138" thick, with U·S·S Cor-Ten .0828" thick, reduced weight 42 lb., cut steel cost 35 cents. When these tanks were shipped to Richmond, Va., freight charges were 72 cents less for the lighter tanks, making a total saving per tank of $1.07.*

"U·S·S Cor-Ten," says the President of Cemline Corporation, "does more than reduce our costs. Because of its stiffness it forms more smoothly on our bending rolls, and fluting difficulties formerly experienced have disappeared. In welding, too, Cor-Ten behaves better than straight carbon steel. It does not seem to burn away so readily under the arc and thus makes welding easier and faster. We know our customers have less trouble and less expense handling these lighter Cor-Ten tanks. And because Cor-Ten has from 4 to 6 times greater atmospheric corrosion resistance we have every reason to believe that Stonesteel tanks made of U·S·S Cor-Ten are much less likely to rust when exposed to external condensation, when leaky fittings drip or when the enameled surface is damaged in shipping or installation. That's why, for all our tanks, except where codes require flange steel construction, we've standardized on U·S·S Cor-Ten."

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
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There is a definite saving of assembly time when you use "UNBRAKO" Socket Head Cap Screws with Knurled Heads. The exclusive Knurled Heads perform triple duty: (1) the *Knurling* provides a sure, slip-proof grip; (2) the *Knurling* speeds assembly, because it enables the "UNBRAKO" to be screwed in faster and further with the fingers—handiest of all wrenches—before a "key" becomes necessary; (3) the *Knurling* permits positive locking—a feature so often essential where there is excessive impact or vibration.

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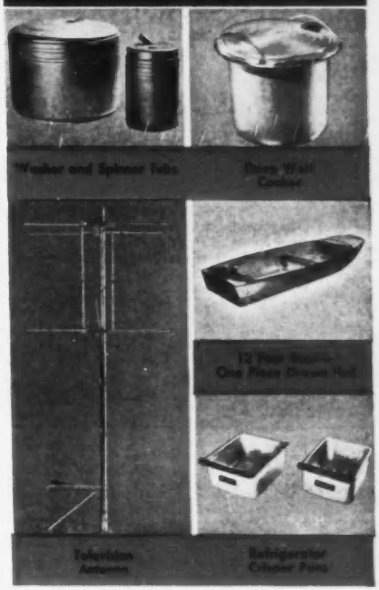

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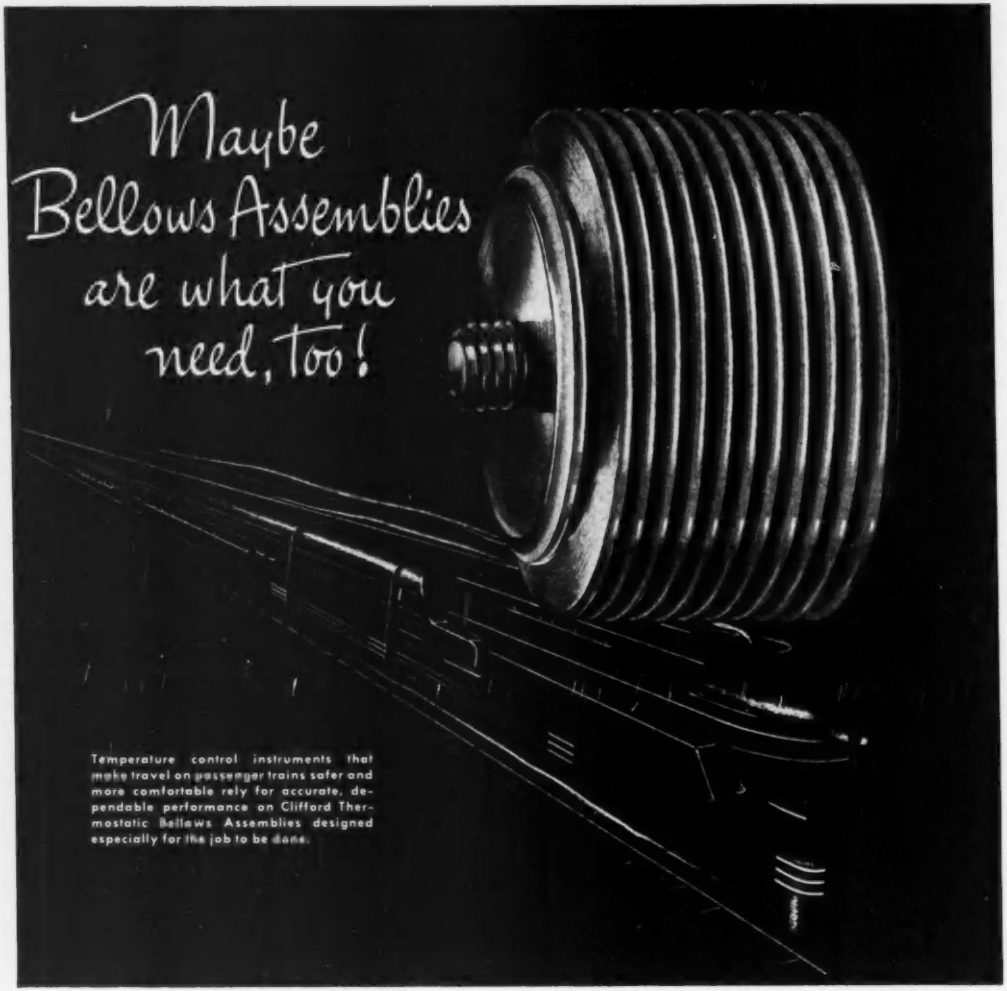
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Whether your problem is controlling temperature or pressure, sealing shafts or valves against leakage, or transmitting motion, it may pay you to investigate bellows assemblies. Doing it before your designs are too far advanced may save you time, trouble and money. Our engineering department will make a confidential analysis of your sketches and specifications and submit recommendations. No cost or obligation involved. CLIFFORD MANUFACTURING COMPANY, 122 Grove St., Waltham 54, Massachusetts. *Division of Standard-Thomson Corporation.* Offices in New York, Detroit, Chicago, Los Angeles.

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no other fastening device gives you all these advantages

RELIANCE SPRING LOCK WASHER ADVANTAGES	WHAT THEY MEAN TO YOU
Adequate Tension	Prevents nut from backing off threads. Compensates for looseness as a result of wear.
Helical Design Coil	Provides, through natural means, maximum reactive range and pressure — keeps bolted assemblies *tighter longer.*
Cold Drawn Spring Steel Section	Section design can be varied to meet the job requirements. Heavier and wider cross sections develop greater reactive pressure. Offers greater fatigue resistance than devices made from light-section flat rolled material.
Bearing Surface for Full Nut	Can be used with any standard or special nuts. Does not depend for security on single-thread engagement and can not be destroyed through over-tightening.
Perfect Hardened Thrust Bearing	Washers are free to rotate, permitting greater tightening torque and reducing to a minimum resistance to tightening from surface friction.
Full Thread Engagement	Direct reactive pressure is exerted between nut face and bolted surface—cannot damage threads.
Wide Variety of Uses	Can be used in any bolted assembly from a locomotive to the smallest scientific instrument.
Made From Various Types Of Metal	Reliance Spring Lock Washers are made from carbon, alloy and stainless steel, K-Monel, bronze and aluminum.
American Standards Association Specifications	Manufactured to the A.S.A. Specifications in all sizes — Reliance Rib, Positive Wood Spring, Springlox, Knolink, Wide Bearing and Double Coil types for special application.
Easy To Use	No special skill required—one piece construction —no parts to come loose or fail. No projections to injure user or damage materials.
Inexpensive	The lowest cost tension fastening device for its weight and combined features on the market.
Eaton-Reliance Manufactured	The Eaton-Reliance reputation and the experience of more than 35 years of spring lock washer manufacture guarantee a commercially-perfect product and assure customer satisfaction.

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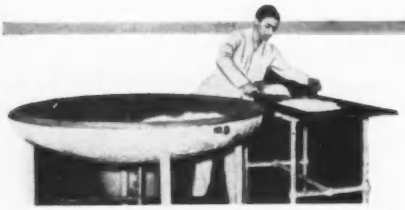
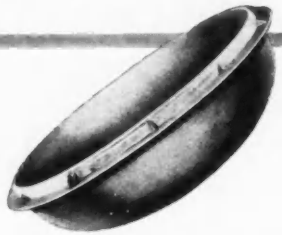
THESE POTS AND PANS ARE BUILT AROUND

Lukens Head-Shapes



EVAPORATING PAN Two Lukens Head-Shapes were joined to make this product. The one on top is made of 20% Nickel-Clad Steel, presenting a corrosion-resistant surface to materials being processed. The one underneath forms a steam jacket for heating the pan.

LEAD DROSSING KETTLE Starting with a Lukens Flanged and Dished Head-Shape 42″ deep by 122″ O.D., Lukenweld added the flange, stress-relieved the assembly and grit-blasted the inside. Then this vessel went to work as a drossing kettle for refining lead.



SUGAR COOKER Varying from 30 to 150 gallons in capacity, from 3 to 5 feet in diameter, hundreds of these kettles have been shipped to South America for boiling sugar syrup. They are simply flanged and dished Head-Shapes, hot-pressed by Lukens.

MELTING POT—The bottom of this 40″ I.D. by 40″ deep pot is a Lukens Flanged Only Head, ¾″ thick. The sides are ⅝″ steel plate. Fabricated by Lukenweld for use on a Lavite annealing furnace, this pot is typical of those available in a wide range of sizes.

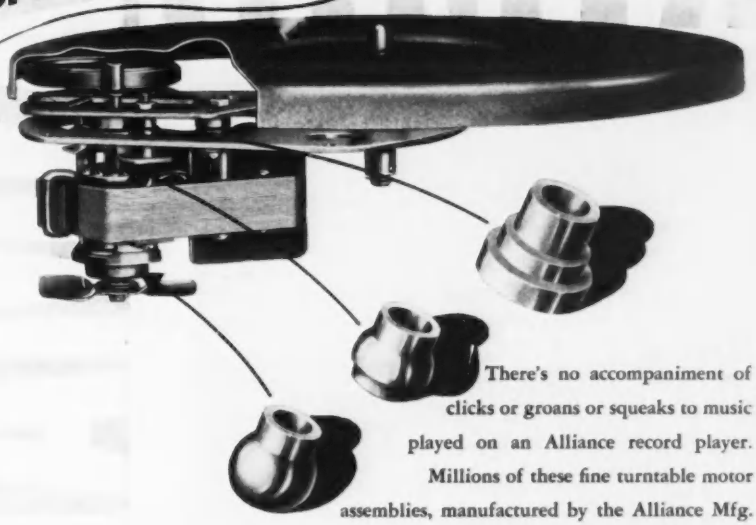
HAVE YOU A PRODUCT which can be built around Lukens Head-Shapes? Their use often saves a manufacturer many hours of labor, by-passes heavy forming operations in his own plant, eliminates expensive machining work, improves his product. Lukens offers hundreds of standard Head-Shapes from which to choose.

Catalog No. 1 describes 3,989 Lukens Heads. For a copy, write Lukens Steel Company, 405 Lukens Building, Coatesville, Pennsylvania.

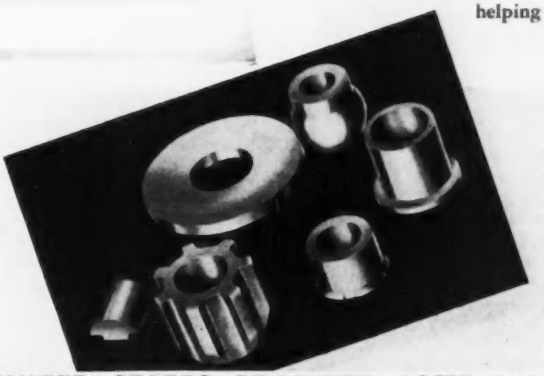
LUKENS HEADS

FOUR INCHES TO OVER TWENTY FEET IN DIAMETER

GRAMIX bearings help insure quiet operation of record player



There's no accompaniment of clicks or groans or squeaks to music played on an Alliance record player. Millions of these fine turntable motor assemblies, manufactured by the Alliance Mfg. Co. of Alliance, Ohio, operates *smoothly, silently —and at constant speed*—thanks largely to three little Gramix bearings. Two self-aligning bearings in the motor and a double flange bearing on the main shaft are not only helping Alliance units give better service but they are also helping Alliance cut their cost of manufacture.



Because bearings, gears and other Gramix parts are die-pressed of powdered metal, they cost far less than machined parts, *sometimes as much as 80% less.* And because they can be impregnated with lubricants, further lubrication of Gramix parts is often unnecessary. Our engineers may be able to show how Gramix can help you improve mechanical performance and cut manufacturing costs in your products. Write today for free copy of the 264 page Gramix catalog.

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Now, assembly costs can be lower and savings higher than ever before. By producing flat-type SPEED NUTS in continuous strip form—Tandem SPEED NUTS—Tinnerman helps solve the critical problem of what to do about production costs.

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When tightened, a partial shear between each SPEED NUT permits the operator to break the strip away quickly, easily and cleanly—ready to move to the next location. Another saving—there's no loss from SPEED NUTS dropped on the floor.

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It's so easy to locate and to hold Tandem SPEED NUTS while tightening.
Snap! The strip breaks off—and is ready for the next bolt.
TINNERMAN
Speed Nuts

Truly compressible gaskets reduce sealing costs on metal-to-metal joints

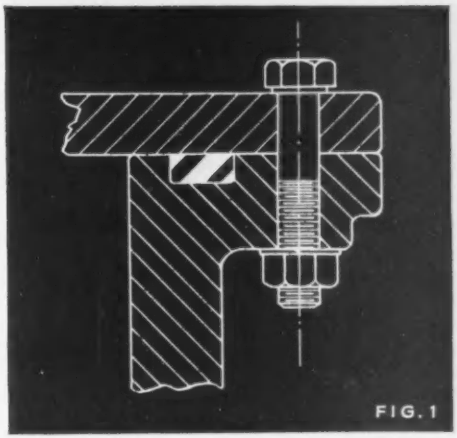
FIG. 1

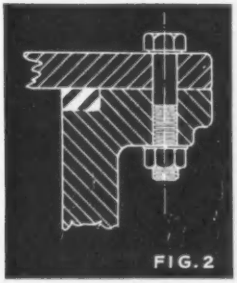
FIG. 2

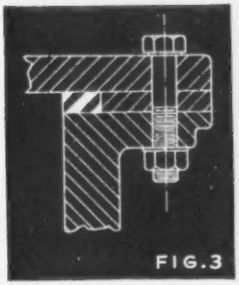
FIG. 3

Sealing costs on rigid, metal-to-metal joints frequently can be reduced with truly compressible gasket materials. Such materials compress under load, actually decreasing in volume. Hence they permit gaskets made to commercial standards to be used on units with extremely close assembly tolerances.

On the flange shown in figure 1, for example, sealing costs were reduced when its molded rubber gasket was replaced with a lathe-cut ring made of a truly compressible Armstrong's Cork-and-Rubber Composition.

Unless close tolerances were maintained, the rubber gasket tended to overflow its channel and interfere with correct mating of the flanges. Cork-and-rubber, on the other hand, compressed into the channel without extrusion. And because cork-and-rubber was lathe-cut instead of being molded, its cost was much less.

Similarly in figure 2, lathe-cut rings of Armstrong's Cork-and-Rubber replaced a rubber gasket and provided an effective, low-cost seal. Here again, tolerances on the rubber gasket had caused trouble. Undersize gaskets tended to creep out of place.

To solve this problem, cork-and-rubber rings were supplied 25% thicker than the depth of the counterbore. Because cork-and-rubber is truly compressible, it compressed without appreciable side flow and eliminated the tendency to creep.

Figure 3 shows how flat flanges were adapted to metal-to-metal sealing by inserting an annular shim between the flanges. As before, the lathe-cut cork-and-rubber gasket reduced sealing costs.

Effective, low-cost seals for units with close assembly tolerances is but one type of problem solved by Armstrong's Cork-and-Rubber. Call your Armstrong representative to see how these materials can help you.

Send for this Gasket Handbook

You'll find useful application and specification data in the revised 24-page booklet, "Armstrong's Gasket and Sealing Materials." It contains up-to-date data on synthetic rubber, cork-and-synthetic-rubber, and cork composition sealing materials.

This booklet includes ten technical discussions of the factors influencing modern gasket and joint design. It also suggests methods of putting Armstrong's stock materials to specialized uses in such fields as radio, electrical, automotive, petroleum, and transportation industries. Also included are typical applications and current government specifications.

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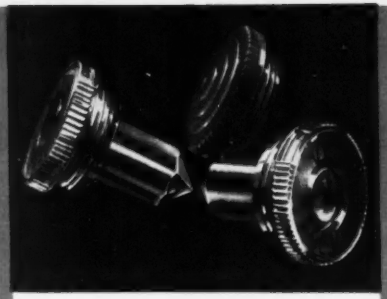

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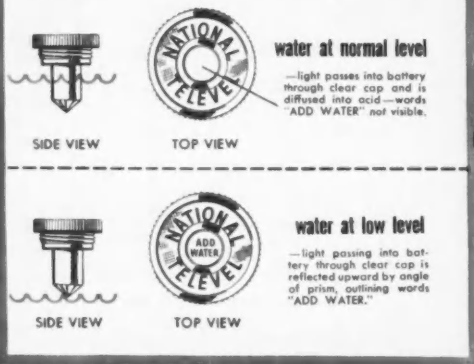
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water at normal level
—light passes into battery through clear cap and is diffused into acid—words "ADD WATER" not visible.
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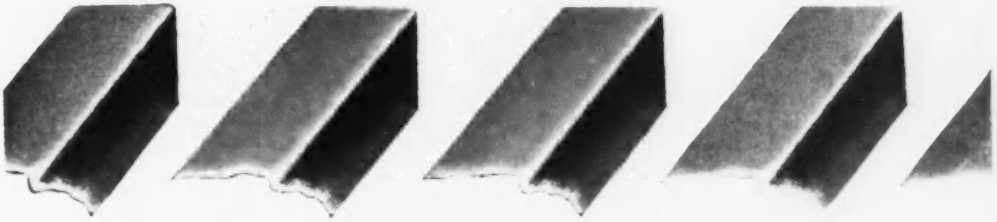

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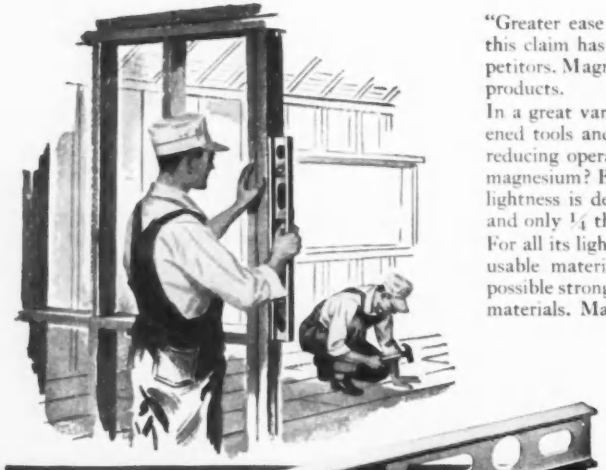

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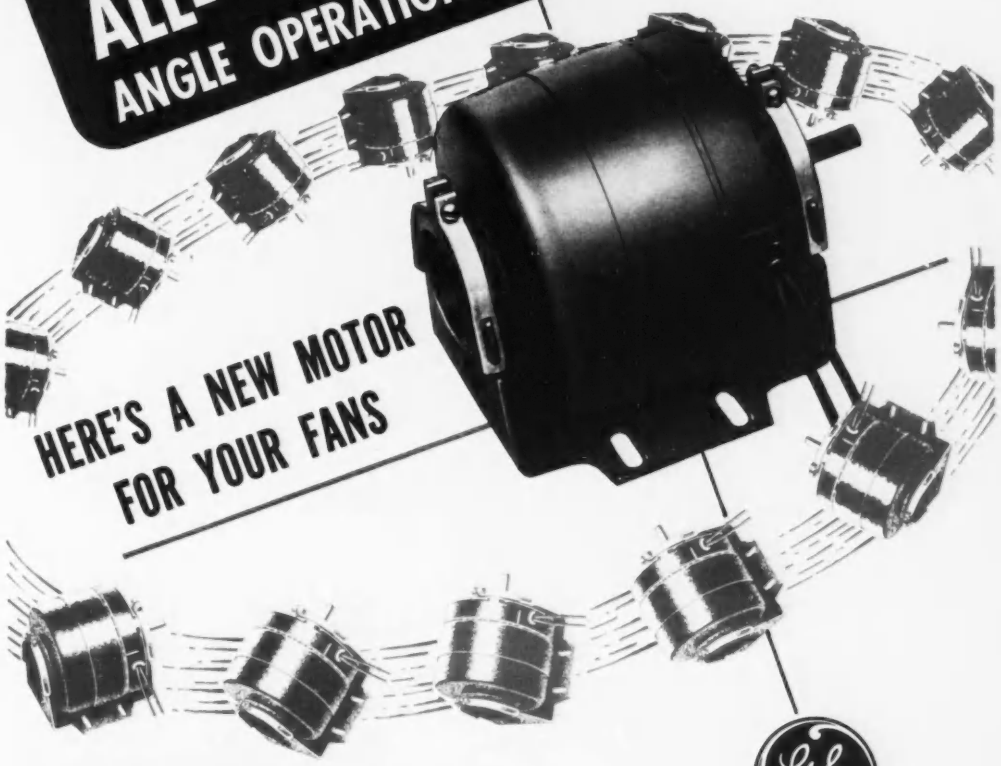

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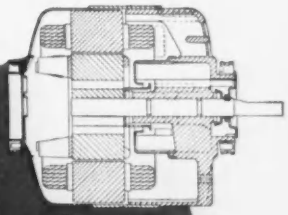

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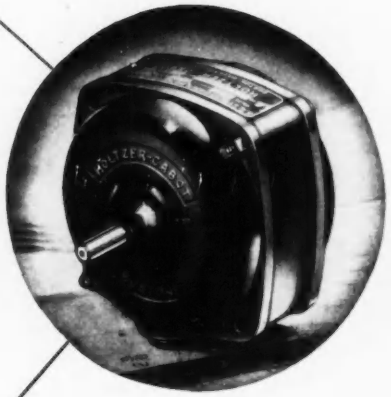
200-100

HOLTZER CABOT



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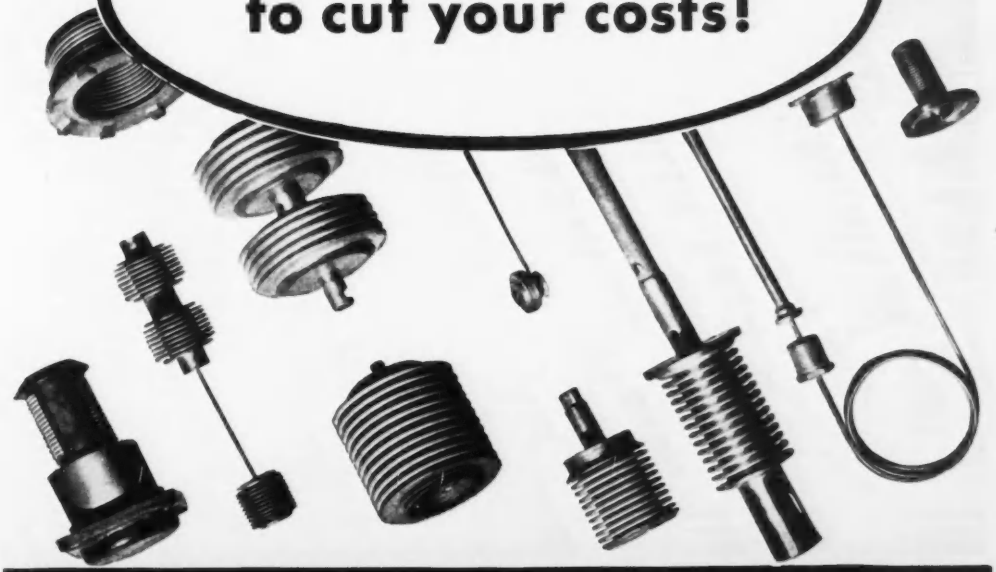

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● No matter how intricate a stainless steel bellows assembly you may require, Fulton Sylphon can produce it for you—and make savings for you to boot!

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Temperature Controls • Bellows Devices • Bellows Assemblies

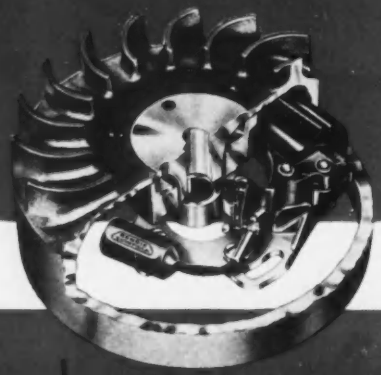
FULTON SYLPHON
DIVISION

ROBERTSHAW FULTON CONTROLS CO. KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

GET ALL of the FEATURES

YOU HAVE BEEN LOOKING FOR



SPECIFY

BENDIX-SCINTILLA

THE MOST TRUSTED NAME IN MAGNETOS

Now you can take advantage of the more than 25 years of experience Bendix-Scintilla has gained manufacturing fine ignition equipment for the aircraft industry. This unparalleled background has enabled Bendix-Scintilla to bring you the ultimate in compact, lightweight magnetos for small industrial, outboard and marine engines. *All* of the features you have been asking for are included—here are truly modern magnetos to meet the performance requirements of modern engines. Above all, when you specify Bendix-Scintilla, you assure the matchless dependability that has made it the most trusted name in magnetos.

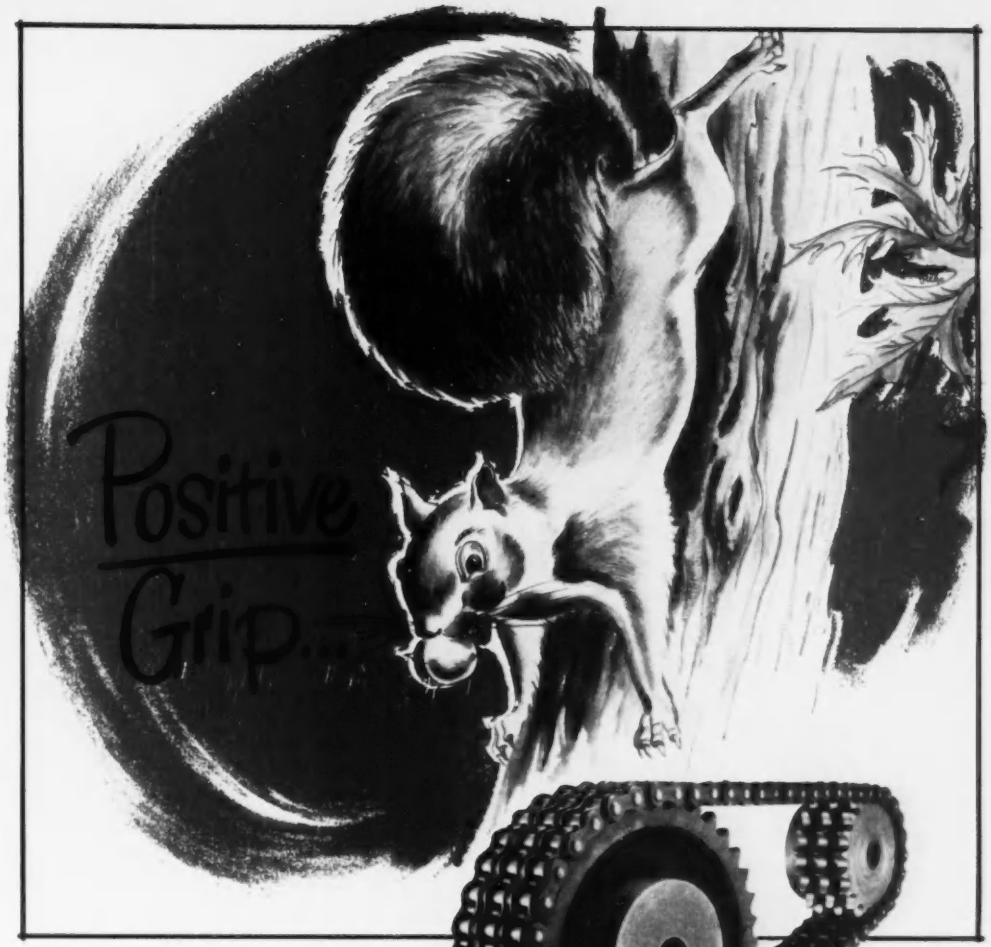
BUILT-IN RELIABILITY

Simplicity in design • Waterproof moulded condenser and coil • Lower operating cost • Minimum lubrication requirements • Light in weight • Higher voltage at starting speeds • Constant spark over entire speed range • Compact and sturdy construction.

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of

SIDNEY, NEW YORK



with WHITNEY Roller Chain Drives

Delivery constant, full power from driver to driver mechanisms . . . that's one of the major advantages of using chain drives.

Deeply seated in the sprocket, Whitney Roller Chain eliminates power loss because there is no slippage or friction loss. This means that full rated horsepower is delivered . . . constant speed maintained . . . highest transmission efficiency always obtained.

In addition, Whitney Chain absorbs shock loads without breakage, assuring long operating life; while the flexibility and adaptability of chain drives simplifies design problems.

For positive power transmission specify and use Whitney Roller Chain . . . the *all steel drive*. Write for information.

CHAIN DRIVE IS BETTER

- Positive Grip
- Transmission of full horsepower
- High resistance to shock loads
- High load carrying capacity
- Simplifying transmission designs
- Low Maintenance
- Ease of installation
- Long operating life
- Constant uniform speeds

WHITNEY CHAIN & MFG. CO.
Division of
Whitney-Manson Industries Inc.
104 Hamilton St.,
Hartford 2, Conn.

"Gee Pop, what a Super Typewriter"

She knows (as you do) This portable's easy handling and smooth performance made her want it. Its fair price made her buy it.

This is the way Alcoa Aluminum Die Castings put an upswing in this manufacturer's sales curve. Their physical properties made the machine handle better and perform better. Their exceptional economy put a purse-loosening price tag on the finished product.

They can do the same for you. Start planning with the book "Designing for Alcoa Die Castings". Ask your Alcoa Sales Office or write ALUMINUM COMPANY OF AMERICA, 611-L Gulf Building, Pittsburgh 19, Pennsylvania.

The Name "Alcoa" Is the Certificate of Quality

Minute percentages of metallic impurities do not "off-grade" Aluminum Alloy Die Castings.

Continuous close control by Alcoa's own laboratories assures constant high quality in die castings produced in Alcoa plants.

The Alcoa trademark is their certification of quality.

ALCOA ALUMINUM Die Castings merit your *FIRST* consideration

ALCOA FIRST IN ALUMINUM

ALCOA ALUMINUM

INGOT • SHEET & PLATE • SHAPES, ROLLED & EXTRUDED • WIRE • ROD • BAR • TUBING • PIPE • SAND, DIE & PERMANENT MOLD CASTINGS • FORGINGS • IMPACT EXTRUSIONS
ELECTRICAL CONDUCTORS • SCREW MACHINE PRODUCTS • FABRICATED PRODUCTS • FASTENERS • FOIL • ALUMINUM PIGMENTS • MAGNESIUM PRODUCTS

A CASE FOR MEDICAL PROGRESS

The Mills-molded Tenite Plastic case for this Clinitest Sugar-Urine Urinalysis set is truly a case for medical progress . . . for it contains another advancement toward the control of Diabetes. This new method of urinalysis provides the diabetic patient with a simplified method of maintaining a more accurate check on his own condition. The Clinitest is a compact, complete unit in itself and eliminates the heating usually needed for urinalysis. Clinitest literature stresses the durability of its plastic case by stating, "The Clinitest case, made of durable TENITE plastic, will last a lifetime with the proper care." Thus the strength of plastic becomes a definite sales asset to this highly specialized product. This effectiveness is a result of Mills' painstaking production analysis. It is typical of the careful attention given all products molded here. Let Mills' planning do the same effective job for your products. We invite your inquiries.

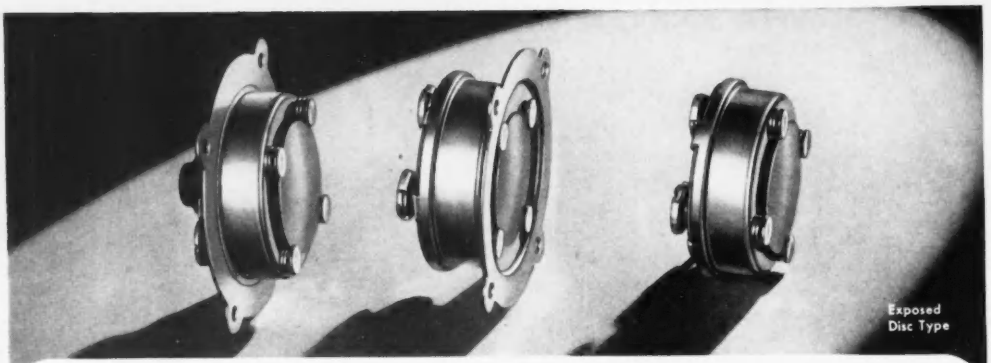
Write on your letterhead for the new Injection Molded and Extruded Plastics catalog. Or, for detailed information about [redacted]* pipe, tubing and fittings, write for circulars containing data and illustrations.

*Trade Mark Reg.

ELMER E. MILLS CORPORATION

INJECTION MOLDERS and EXTRUDERS of Tenite, Lumarith, Plastacele, Lucite, Nylon, Ethyl Cellulose, Plexiglas, Polystyrene, Styron, Loalin, Vinylite, Geon, Plexene, Polyethylene, Cerex, Forticel, [redacted]*, Saran, and other Thermoplastic Materials.

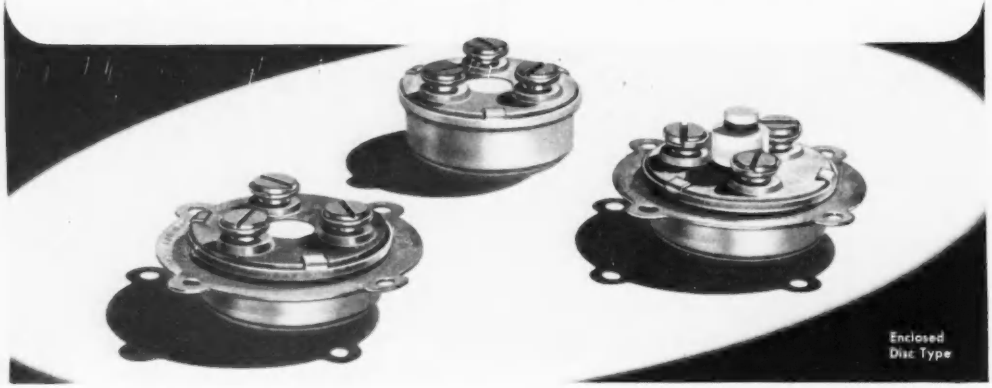
2930 NORTH ASHLAND AVENUE • CHICAGO 13, ILLINOIS



Announcing the New

KLIXON THERMOSNAP CONTROLS

for products requiring non-adjustable Temperature Controls

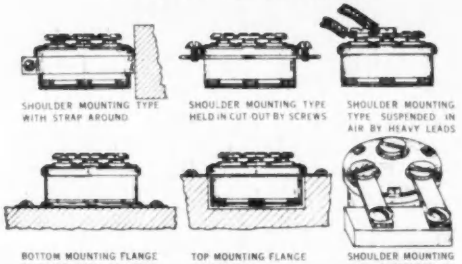


The new Klixon, C4370 types, Thermosnap Controls are especially designed for such control applications as unit and space heaters, small water heaters and many other products requiring non-adjustable temperature control. These control units are available with enclosed contacts and exposed operating disc for fast thermal response . . . or with both contacts and thermal disc enclosed for greater protection against dust, oil, dirt, etc.

Klixon type C4370 Controls are listed by Underwriters' Laboratories for use where proper terminal enclosure is provided. This eliminates the need for further testing of the thermostat when applied to products requiring Underwriters' listing.

Klixon Thermosnap Controls can be supplied with various temperature differentials in settings from minus 10° to 550°F. . . . Manual reset type including reset button also available. They are simple to mount. (See typical mounting illustrations at right.) Write for information.

TYPICAL MOUNTINGS


SHOULDER MOUNTING TYPE WITH STRAP AROUND
SHOULDER MOUNTING TYPE HELD IN CUT-OUT BY SCREWS
SHOULDER MOUNTING TYPE SUSPENDED IN AIR BY HEAVY LEADS
BOTTOM MOUNTING FLANGE TYPE MOUNTED ON FLAT SURFACE
TOP MOUNTING FLANGE TYPE IN WELL
SHOULDER MOUNTING TYPE SUSPENDED IN AIR BY BUS-BARS

KLIXON

TRADE MARK REG. U.S. PAT. OFF.

SPENCER THERMOSTAT

Division of Metals & Controls Corp.

911 FOREST STREET, ATTLEBORO, MASSACHUSETTS

HERE'S THE ALL-PURPOSE SWITCH

Approximately full size

* it's the.... SB-1 CONTROL AND TRANSFER SWITCH

DESIGN engineers have already utilized the SB-1 for over 10,000 control combinations on circuits up to 20 amperes at 600 volts a-c or d-c.

Standard parts and a simple basic design mean longer life and low initial cost to you. There's a *standard* SB-1 for most jobs, and they're ready on four weeks' delivery. If a standard can't satisfy, we'll build what you want from standard cams, contacts, and fingers of the basic design.

A variety of attractive switch handles, and watertight, dust-tight, oil-immersed, fabricated-metal, or explosion-proof housings are available to fit your particular installation problems. Mount on panels $\frac{1}{8}$ to 2 inches thick. Switch shown is $8\frac{1}{4}$ inches over all, $2\frac{3}{4}$ inches wide, $4\frac{1}{4}$ inches high.

Why not try an SB-1 on your particular control problem? Your nearest General Electric sales representative will be glad to assist you in the selection of an SB-1. Also, ask him for a copy of GEA-4746 that gives additional information about the SB-1, or write to *Apparatus Department, General Electric Company, Schenectady 5, New York.*

GENERAL ELECTRIC

Another Houghton "first"—a request to the packing industry from large users, which was promptly met by Houghton, and Houghton alone!

The Joint Industry Conference on packing standards has accepted our engineers' recommendations on how to promote interchangeability of packing sizes, reduce the number and adopt uniform "dash" numbers and coding for users' machine plates.

All of which should indicate that Houghton experience was of definite aid. Have you a copy of the "Packing Standards" free book which explains the whole project? Write for it.

Engineering aid to industry and to individual designers has long been a prime reason why men who have hydraulic problems come to Houghton.

But our primary business is making and selling packings. They include all standard types of VIM Leather and Vix-Syn synthetic rubber packings, "O" rings and leather back-up washers.

May we quote on your production needs, with the assurance that your individual packing problems will be painstakingly handled? E. F. Houghton & Co., Philadelphia 33, and all principal cities.

HOUGHTON'S VIM LEATHER and VIX-SYN PACKINGS

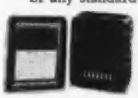
ANNOUNCING A NEW DISC TYPE BRAKE FOR ELECTRIC MOTORS

THIS REVOLUTIONARY NEW BRAKE GIVES YOU ALL THESE ADVANTAGES:

- Instant Operation
- Fast Controlled STOPPING
- NO adjustment for life
- Unmatched ability to dissipate heat
- Fewer parts
- Compactness and ease of installation
- Low power requirements— max. 25-35 watts
- Low cost installation and maintenance

POWER CONVERSION UNIT

Warner brake coils are wound for full current application of 90 Volts D.C. D.C. power may be obtained from a D.C. source or any standard A.C. supply with a Warner conversion unit. Warner conversion units supply a maximum of .40 amperes at 90 Volts D.C. when connected to any A.C. voltage source.



New Warner disc type electric brakes for electric motors exert a constantly increasing torque throughout stopping period. Standard units now available for horizontal shaft mounting. All Warner disc type electric brakes for electric motors are designed to fit NEMA motor specifications. These units have been thoroughly field tested and yield amazingly practical results. Write today for complete information.

WARNER
ICB UNIT

Warner Electric Brakes for Transportation and Industry Since 1927

WARNER ELECTRIC BRAKE MFG. CO.
BELOIT, WISCONSIN

Please send me bulletin 702 with complete information on Warner Electric Disc-Type Brakes for Electric Motors.

Name.....

Company.....

Address.....

City.....Zone....State.....

Two Leaders of Industry

COMBINE SKILLS AND PRESENT

the FOOTE BROS.—LOUIS ALLIS GEARMOTOR

LOUIS ALLIS

THE LOUIS ALLIS COMPANY

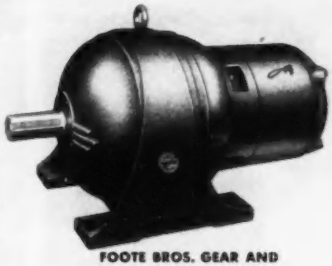
Three generations of designing and building special motors for special applications by THE LOUIS ALLIS COMPANY—plus the creating, developing, and pioneering of many special types of motors for special operating conditions—give you one of—if not THE largest selection of sizes and types of standard and special motors in the entire industry today.

The specialized engineering and manufacturing experience and facilities of FOOTE BROS. GEAR AND MACHINE CORPORATION and THE LOUIS ALLIS COMPANY are now available to industry through the separate sales, service, and manufacturing organizations of both Companies.

The combination of these two quality products into one compact, efficient gearmotor reflects the earnest desire of both firms to better serve industry through their combined skills.

To be available in single, double, and triple reduction in ratings of 1 h.p. through 75 h.p. with open drip-proof, enclosed, splashproof, and explosion-proof motors.

FOOTE BROS.



FOOTE BROS. GEAR AND MACHINE CORPORATION

Back of Foote Bros. is nearly a century of engineering knowledge and manufacturing experience plus the latest in gear generating equipment, all of which assure the highest quality in gear design and production. Foote Bros. complete line includes helical and worm drives to meet practically any industrial requirement.

On your very next gearmotor application Specify Foote Bros.-Louis Allis Gearmotors

THE LOUIS ALLIS COMPANY
427 East Stewart Street
MILWAUKEE 7, WISCONSIN

For quick, dependable service—contact nearest Louis Allis or Foote Bros. Gear and Machine Corporation sales office—or write to the home office of either company.

FOOTE BROS. GEAR AND MACHINE CORPORATION
4545 South Western Boulevard
CHICAGO 9, ILLINOIS

FOR COPY OF GEARMOTOR BULLETIN WRITE TO EITHER COMPANY

Now!

More accurate precision castings of intricate parts... at new low cost

Special formulation Lustrex 15K opens new horizons in precision casting

Sturdy, durable, easy-to-handle patterns of new Lustrex 15K (top) produce extremely accurate castings as shown in this sample (bottom). Equally important is that Lustrex 15K enables precision casters to produce superior articles... at lower costs. *Manufactured for Indian Motorcycle Co. by Midwest Foundry Division of L. A. Darling Co., Coldwater, Mich.*

Here's good news for manufacturers looking for a combination of extremely accurate castings . . . and new low costs: Precision casters are now producing *more accurate components*, with far lower die and tooling costs, lower production and handling costs . . . using a new special material manufactured by Monsanto.

Precision casting is now more ***practicable*** than ever before! This outstanding new formulation, developed by A. R. D. Corporation and manufactured solely by Monsanto for sale to precision casters through A. R. D., replaces expensive, fragile, hard-to-handle wax patterns used in ordinary casting processes. With high dimensional stability, the new patterns increase accuracy and facilitate production of intricate parts.

Best of all, this special A. R. D. process delivers your parts at low cost. Inexpensive zinc alloys can be used to cut die costs; and present equipment (including low pressure machines) can be readily and easily adapted.

In addition, use of Lustrex 15K patterns permits flexible scheduling of the precision caster's plant operations (these patterns may be stored and used later when machines are free); and the patterns are exceptionally easy to handle. Result: lower costs for precision casting.

Manufacturers: Here's opportunity for you to produce finer, more saleable, less expensive products. Why not write (or have your precision caster write) *today* for descriptive literature and technical data on this new process. Address: A. R. D. Corporation, 70 Pine Street, New York, New York.

Perhaps Monsanto can also help *you* replace other old, unsatisfactory materials with a modern plastic . . . tune up production, cut costs, boost sales . . . and profits. Write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Mass.

Patents pending on Lustrex 15K

FOR A BIGGER DOLLAR'S WORTH, BUY AND USE MONSANTO PLASTICS.

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICALS — PLASTICS

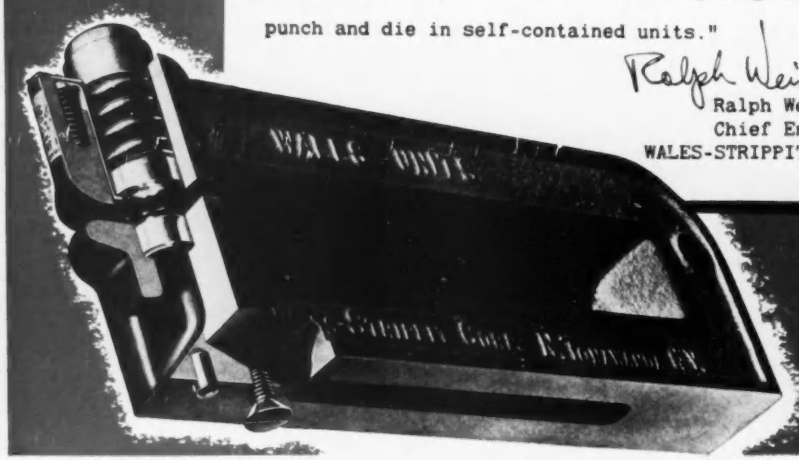
THE LARGEST FAMILY OF PLASTICS IN THE WORLD

A Chief Engineer speaks . . . about MEEHANITE Castings

"Meehanite castings provide the combination of qualities that definitely contributes to the successful manufacture and function of our sheetmetal perforating units. Their ability to take a smooth finish and their wear resisting properties greatly increases the life of the units. The freedom from warpage or movement after machining found in Meehanite castings is of utmost importance in maintaining alignment of punch and die in self-contained units."

Ralph Weisbeck

Ralph Weisbeck
Chief Engineer
WALES-STRIPPIT CORPORATION



Cut-away view of a Wales type "BL" Hole Punching Unit. Many size punch holders of this type are made of Meehanite castings for the Wales-Strippit Corporation, North Tonawanda, N. Y.

The above statements express the importance of dependability and quality to those who carefully select and specify required engineering characteristics for their components. In the manufacture of Meehanite castings control of metal structure permits achievement of desired properties. When you insist upon Meehanite castings you are insuring just such benefits and economies plus built-in quality of your equipment.

For details covering a wide range of general industrial applications write for our four volume series "Meehanite Means Better Castings."

MEEHANITE FOUNDRIES

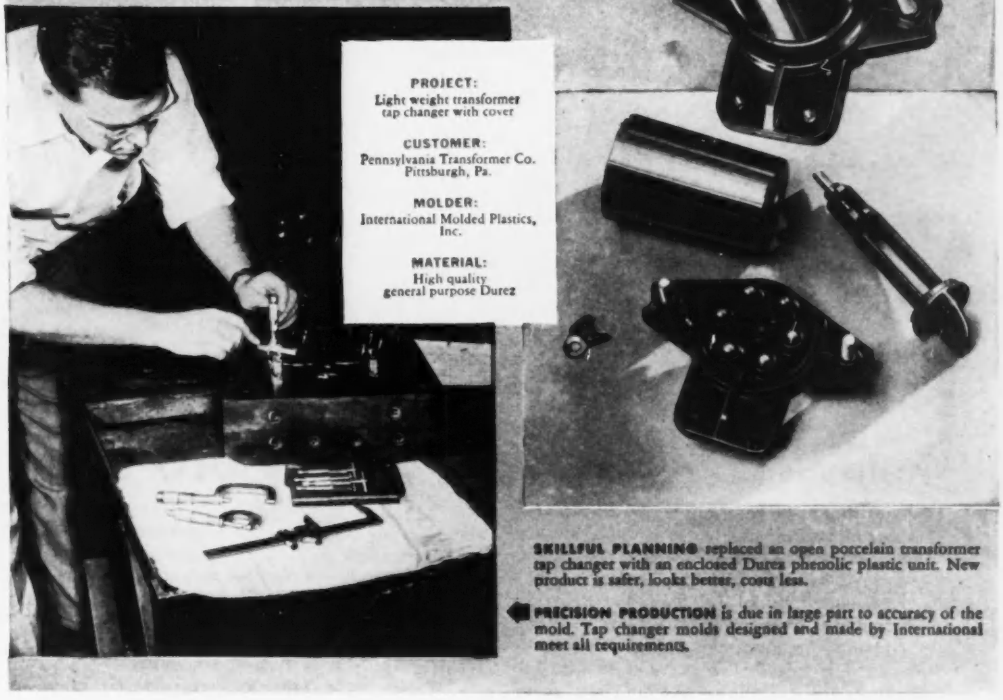
American Brake Shoe Co. — Mahwah, New Jersey	General Foundry & Manufacturing Co. — Flint, Michigan	Russ-Meehan Foundries — Chattanooga, Tennessee
The American Laundry Machinery Co. — Rochester, New York	Greenlee Foundry Co. — Chicago, Illinois	Shenango-Penn Mold Co. — Dover, Ohio
Atlas Foundry Co. — Detroit, Michigan	The Hamilton Foundry & Machine Co. — Hamilton, Ohio	Smith Industries, Inc. — Indianapolis, Ind.
Banner Iron Works — St. Louis, Missouri	Johnstone Foundries, Inc. — Grove City, Pennsylvania	Standard Foundry Co. — Worcester, Massachusetts
Barnett Foundry & Machine Co. — Irvington, New Jersey	Kanawha Manufacturing Co. — Charleston, West Virginia	The Stearns-Roger Manufacturing Co. — Denver, Colorado
H. W. Butterworth & Sons Co. — Bethayres, Pennsylvania	Koehring Co. — Milwaukee, Wisconsin	Traylor Engineering & Mfg. Co. — Allentown, Pennsylvania
Continental Gin Co. — Birmingham, Alabama	Lincoln Foundry Corp. — Los Angeles, California	U. S. Challenge Co. — Centerville, Iowa
The Cooper-Bessemer Corp. — Mt. Vernon, Ohio and Grove City, Pa.	E. Long Ltd. — Orillia, Ontario	Valley Iron Works, Inc. — St. Paul, Minnesota
Crawford & Doherty Foundry Co. — Portland, Oregon	Otis-Fensom Elevator Co., Ltd. — Hamilton, Ontario	Vulcan Foundry Co. — Oakland, California
Farrel-Birmingham Co., Inc. — Ansonia, Connecticut	The Henry Perkins Co. — Bridgewater, Massachusetts	Warren Foundry & Pipe Corporation — Phillipsburg, New Jersey
Florence Pipe Foundry & Machine Co. — Florence, New Jersey	Pohlman Foundry Co., Inc. — Buffalo, New York	"This advertisement sponsored by foundries listed above."
Fulton Foundry & Machine Co., Inc. — Cleveland, Ohio	Rosedale Foundry & Machine Co. — Pittsburgh, Pennsylvania	

Meehanite® NEW ROCHELLE, N. Y.

It pays to use your custom molder's know-how

says another electrical equipment producer

No. 11 in a series on Plastics Skill at Work . . .



SKILLFUL PLANNING replaced an open porcelain transformer tap changer with an enclosed Durez phenolic plastic unit. New product is safer, looks better, costs less.

PRECISION PRODUCTION is due in large part to accuracy of the mold. Tap changer molds designed and made by International meet all requirements.

● This example of profitable molder-customer relations is interesting, not because it is unusual but for a precisely opposite reason—because it is typical.

Pennsylvania Transformer Company showed their custom molder an improved design that met higher safety standards than previous models. Following the custom molder's habit of applying constructive thought before going ahead, this molder suggested engineering changes that led to better molding technique, greater operating efficiency, and lower production costs.

Plastics men with practical know-how and active interest in their customers' problems can be of profitable service to your design and production departments. Their skill with the versatile Durez phenolics should help you in developing products that look better, wear longer, and sell faster.

Deciding which phenolic compound will do the job best is a small part of a good custom molder's field of cooperation. Call your molder in early, when he can be of greatest service. It's an advantage, too, when you have the specialized experience of a Durez field technician at your planning sessions.

A new hit with plastics users everywhere is the handy "Durez Check-Chart." Write for yours. Durez Plastics & Chemicals, Inc., 1311 Walck Rd., N. Tonawanda, N. Y.

DUREZ

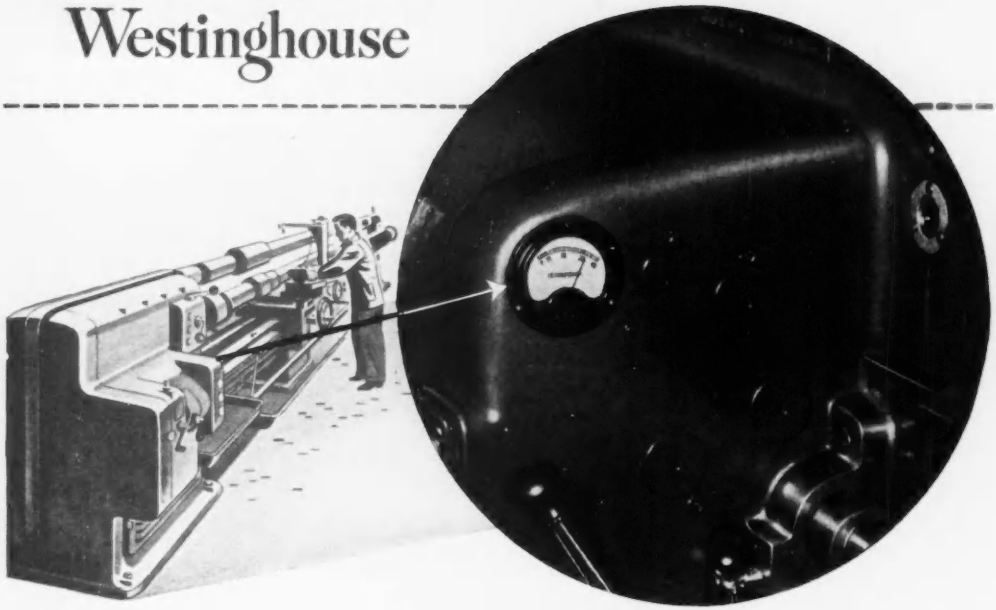
PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- PROTECTIVE COATING RESINS

PHENOLIC PLASTICS THAT FIT THE JOB

YOU CAN BE **SURE**.. IF IT'S

Westinghouse



This Westinghouse Instrument helps set *New Production Records*

Savings in machine time up to 75% are common among the users of the American Tool Works Company's new hydraulic duplicating lathes!

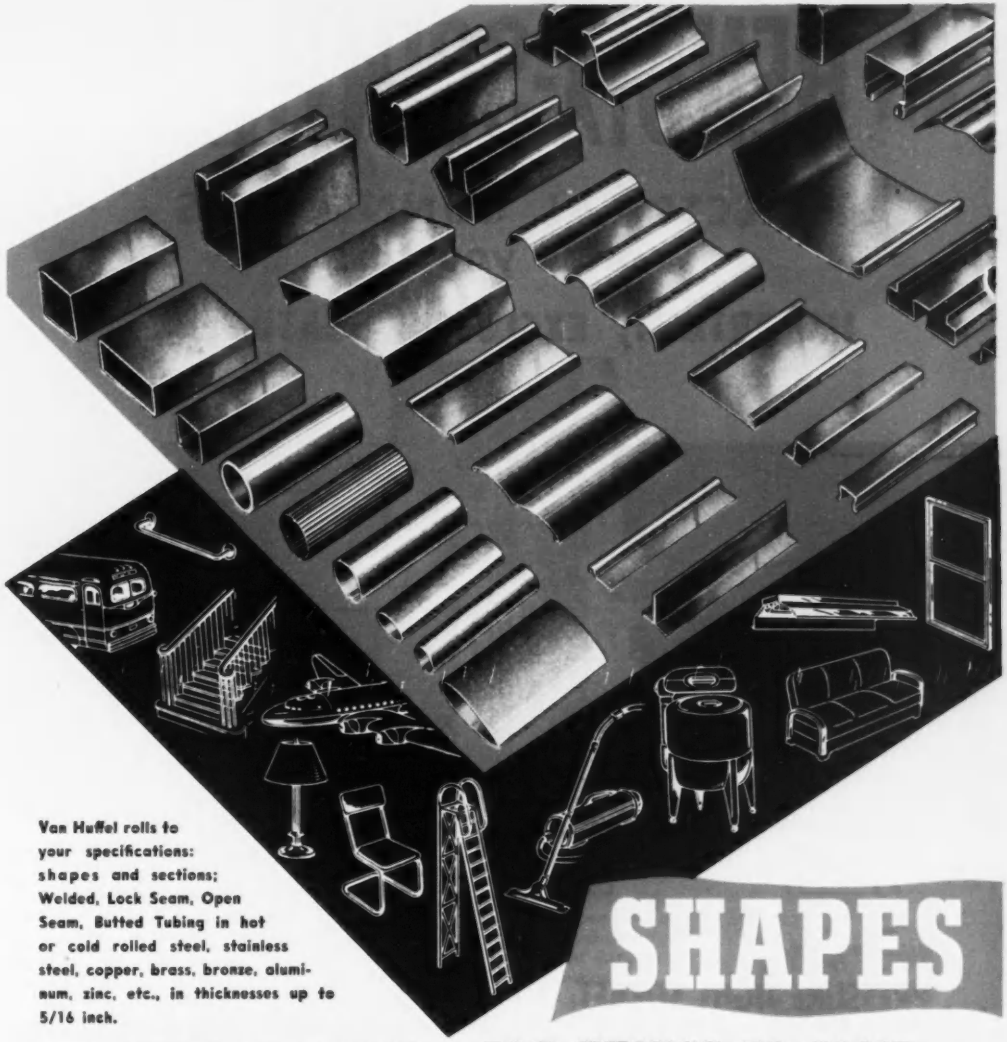
A standard feature of these lathes is the Westinghouse horsepower instrument. It shows, at a glance, the horsepower being consumed by the cut. This enables the operator to take full advantage of the capabilities of the machine and to make maximum cuts without overloading. Machines can be easily operated at peak loads, without the dangers of overtaxed motors and damaged cutting tools.

This is another example of the application of Westinghouse instruments to *specific* problems. Westinghouse instruments are *engineered* and built to give you reliable performance in *every* application. The completeness of the line means electrical measuring instruments to fill *your* needs exactly in every field of industry.

Westinghouse instrument specialists are available in the field for consultation. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40373

Westinghouse

ELECTRICAL MEASURING INSTRUMENTS FOR *ANY* JOB



Van Huffel rolls to your specifications: shapes and sections; Welded, Lock Seam, Open Seam, Butted Tubing in hot or cold rolled steel, stainless steel, copper, brass, bronze, aluminum, zinc, etc., in thicknesses up to 5/16 inch.

SHAPES

FOR THINGS TO COME . . .

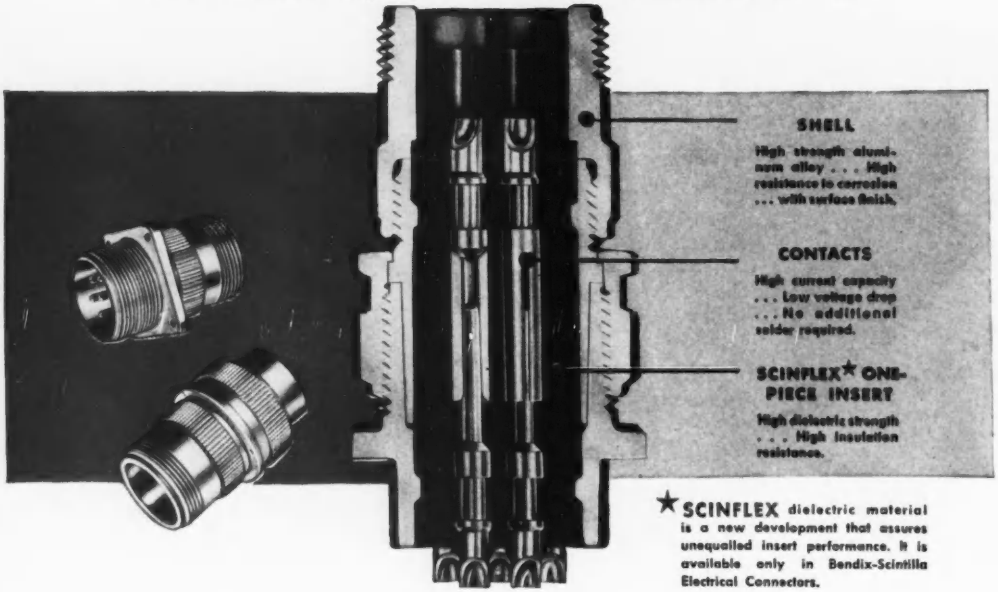
Along with demands for new and better products in the future comes the cry to reduce the cost of producing them. That's why the Van Huffel method of building its own forming mills and dies as well as rolling shapes and tubing is gaining such wide acceptance. Battleships or baby buggies . . . toys or television equipment . . . whatever your product—whether it's now in production or among "things to come", chances are that some of Van Huffel's shape or tubing ideas might be applied to your advantage. We invite you to write for illustrated brochure showing the wide range and diversified applications of Van Huffel Shapes and Tubing.

VAN HUFFEL TUBE CORPORATION · WARREN · OHIO

ONLY BENDIX-SCINTILLA

ELECTRICAL CONNECTORS offer you this

IMPORTANT, EXCLUSIVE FEATURE . . .


SHELL
High strength aluminum alloy . . . High resistance to corrosion . . . with surface finish.
CONTACTS
High current capacity . . . Low voltage drop . . . No additional solder required.
SCINFLEX★ ONE-PIECE INSERT
High dielectric strength . . . High insulation resistance.

★**SCINFLEX** dielectric material is a new development that assures unequalled insert performance. It is available only in Bendix-Scintilla Electrical Connectors.

. . . PRESSURE TIGHT SOCKET CONTACT ARRANGEMENTS!

Outstanding design and fine workmanship, combined with materials that will meet every requirement, make possible our "pressurized" connectors that include both pin and socket arrangements for ALL sizes of contacts.

PLUS ALL THESE OTHER FEATURES

- Moisture-proof
- Radio Quiet
- Single-piece Inserts
- Vibration-proof
- Light Weight
- High Insulation Resistance
- Easy Assembly and Disassembly
- Fewer Parts than any other Connector
- No additional solder required

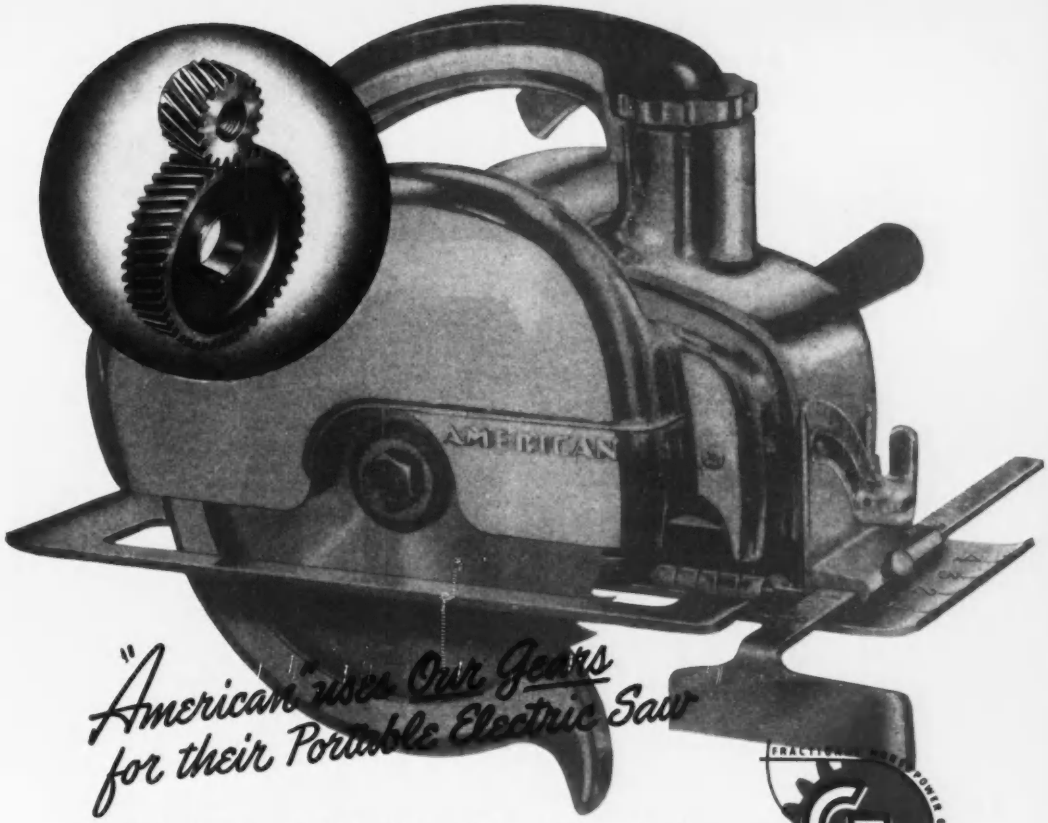
Write our Sales Department for detailed information.

BENDIX SCINTILLA

SCINTILLA MAGNETO DIVISION of [illegible]

SIDNEY, NEW YORK

[illegible]



"American" uses Our Gears for their Portable Electric Saw

THE American Floor Surfacing Machine Co. is well known for the rugged dependability of their portable electric equipment. Important components in the sensational new portable electric saw by "American" are the alloy bronze Gear and the heat treated alloy steel Helical Pinion Gear made by our skillful craftsmen. G.S. Fractional Horsepower Gears contribute substantially to the smooth operation, long life and all round efficiency of this *better* saw. If the *quantity* production of finer, *more uniform*, Small Gears is an essential requirement in your business, by all means take advantage of the highly specialized service we give. *Today* . . ask our engineers for suggestions, and low cost estimates. You won't be obligated to buy.

SEND FOR OUR CATALOG BULLETIN

GEAR Specialties

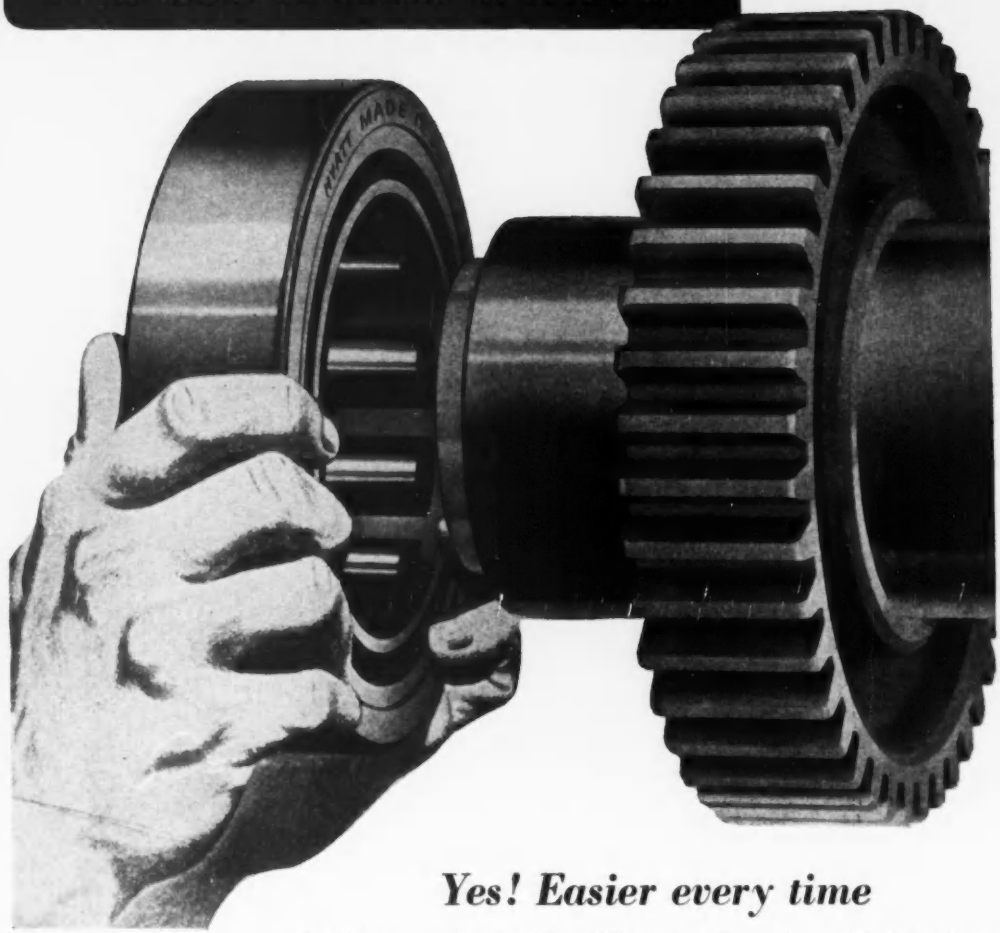
Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

MEMBER OF

2635 WEST MEDILL AVENUE · CHICAGO 47, ILLINOIS

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

"It's easier with HYATTS"



Yes! Easier every time

Why? Because, the straight radial construction and complete interchangeability of bearing parts in Hyatt Hy-Load Bearings make it easier for you.

How? Well, for example, you can mount separable bearing parts on one subassembly and install the balance of the bearing in another, then, bring the subassemblies together completely confident that all bearing parts will fit perfectly.

And there will be no adjustments, no matching, and no blind fitting. There will be nothing to slow down or complicate your final assembly operation.

With more than fifty years of accumulated bearing application experience, we believe we can help you to make real savings in assembly costs. Let us show what we can do for you. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

WRITE

For our interesting and informative booklet "Guide Lines for Engineers and Designers".

HYATT ROLLER BEARINGS

Wiring Components FOR PRODUCT DESIGN

Now—No Fraying No Kinking

It's PREEN-X

THE NEW IDEA IN HEATER CORDS

Here's a really new idea in a heater cord set—General Electric Preen-X heater cord equipped with the handsome General Electric "400" plug.

Preen-X heater cords come with ends stripped and twisted ready for fast installation. They help speed-up assembly, provide an added sales feature. Preen-X has no braid to fray or unravel. Its tough, flexible-insulation jacket—*by actual tests*—takes ten times the abrasion of ordinary heater cords. Preen-X resists water and oil—looks smart on any up-to-the-minute appliance.

The bright, colorful "400" plug makes an attractive-looking companion piece to the new Preen-X heater cord. Made of tough plastic in attractive colors, this gleaming plug adds sales appeal to appliances—attracts customer attention. Strong prongs and sturdy construction make the "400" plug a long-life item.

Before you specify another foot of heater cord, it will pay you to look at Preen-X. For a free sample and all of the facts on this new fray-resistant, non-kinking heater cord, check "A" in the coupon below.

Formex® Magnet Wires

Deltabeston® Magnet Wires

2 great magnet wires from a single source

TO FILL EVERY WINDING NEED

To provide a full range of sizes, shapes, and insulations for a wide variety of applications . . . General Electric offers two great names in magnet wires—Formex, for temperatures to 105 C; and Deltabeston, for temperatures to 125 C.

Formex is the tough, workable magnet wire, insulated with synthetic resin, that is famous for speedy winding and extremely long operating life. Chemical-resistant, heat-shock resistant, abrasion-resistant, space-saving Formex magnet wires are available in all common sizes and shapes.

Deltabeston magnet wires, insulated with glass or with asbestos, are the high-heat magnet wires that permit operation at temperatures higher than those allowable for ordinary cotton- or enamel-insulated wires. Deltabeston magnet wires are available in all the usual sizes and shapes.

For samples of these two famous General Electric magnet wires and the latest booklet containing complete detailed information just check "B" in the coupon below.

LOST!

One repeat sale

"Just look at this frayed cord. Why don't 'they' put durable cords on appliances?"

Why run the risk of being the "they" she's talking about?

Long-lived, good-looking General Electric Flamenol® rip cords are made to bring products through tough situations and to keep them performing well. They're the cords designed to give your product a selling edge over competition before the sale. And they keep your product sold after the sale—that critical period when customers really learn about product quality in terms of day-in, day-out use.

Flamenol cords resist acids, alkalies, water, and oils. Your customers will like the smooth, extra-flexible Flamenol jacket that is easily cleaned with a quick wipe—always looks neat. You'll like the way they can be stripped, quickly and cleanly, for fast installation.

Why not see what these long-wearing cords can do to help your sales and manufacturing picture? To get the facts just check "C" in the coupon.

General Electric Company (Section LS-1167)
Construction Materials Department
Bridgeport 2, Connecticut

Please send me, free, the following:

A ☐ Sample and data on Preen-X—the newest in heater cords.

B ☐ Information and samples of Formex and Deltabeston Magnet Wires

C ☐ Data on General Electric Flamenol rip cords

Name_____

Company_____ **Title**_____

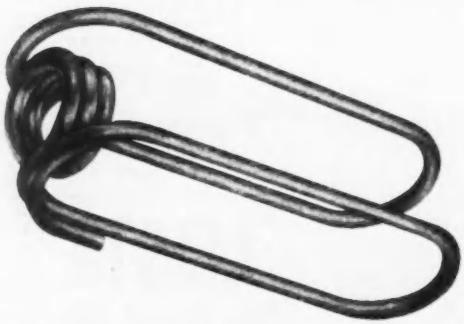
Street_____

City_____ **Zone**____ **State**_____

GENERAL ELECTRIC

LOOKING FOR A NEW

Twist?



Wallace Barnes Springs

Bristol Connecticut

YOU CAN BE **SURE**.. IF IT'S

Westinghouse

MOTOR EXCHANGE SERVICE

For Westinghouse
single-phase and three-phase
1 to 20 hp
frame 203 to 326 a-c motors

Another Life-Line First!

The Broadest Exchange Plan!

Since February, 1949, Life-Line motors have offered you the broadest exchange plan in industry. All 1 to 20-hp, single-phase and three-phase a-c motors in frame 203 to 326 are included. No other manufacturer of motors—large or small—provides exchange service that compares in scope to this new Life-Line Motor Exchange Service.

120 Westinghouse exchange points assure you rush motor replacement service anywhere in the United States. Replacement motors, covered by this plan, are in stock, ready to be speeded to you at any time.

And what's more, if a motor fails during warranty period, it may be exchanged *free* for a motor of identical rating. The *exchange price,* beyond warranty, *is not dependent on the time in service . . . one year, five years or ten years.*

This service is one more advantage you get with Life-Line motors. Add this to all-steel construction . . . pre-lubricated bearings . . . an indicated savings of $750 per year per 100 motors . . . and you'll see why Life-Line has gained leading acceptance in the motor industry.

Complete details on the Life-Line Exchange Service—lists of exchange points and motor ratings covered—are given in the new booklet SM-5243. Get your copy today from your nearby Westinghouse representative or write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-21533

Westinghouse *Life-Line* **Motors**

Wondering made these adhesives do wonderful things

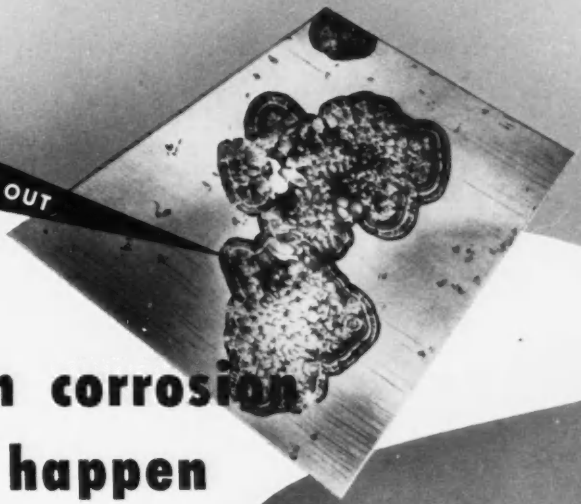
When you start prodding your imagination with phrases like "I wonder if we could possibly . . . ," try turning your thoughts to Armstrong's Adhesives. These modern adhesives are making a lot of business dreams come true. Take, for example, the manufacturer who wondered if his toys could be made more child-resistant. Or the man who wished he could train roses on hooks adhered to garden walls. Or the industrialist who wanted to join a continuous enameled steel skin to a suitable backing. All of these things can be done, of course, with the right adhesives.

The right adhesive may help realize your ideas, too. If one of the fifty odd adhesives in our regular line won't do what you have in mind, there may be an experimental product in our laboratory that will. So don't spare us, even if your needs seem rather fantastic. We may not come up with the answer, of course, but we promise you a good try. Write Armstrong Cork Company, Industrial Adhesives Dept., 6811 Arch St., Lancaster, Pennsylvania.

ARMSTRONG'S ADHESIVES

Made by the makers of Armstrong's Linoleum

WE WOULD LIKE TO POINT OUT



underfilm corrosion just *Can't* happen with

Weirzin

ELECTROLYTIC ZINC-COATED SHEETS AND STRIP

Paints, enamels, lacquers, varnishes and lithographic inks adhere to Weirzin securely and permanently, because underfilm corrosion cannot occur. The tight, malleable zinc coating, electrolytically applied, becomes an integral part of the sheet or strip . . . remains intact under all conditions of temperature and humidity . . . provides a perfect "tooth" for spray, dip or roller applications.

Extensive fabrication does not weaken this bond—after deep-drawing, forming and punching, the zinc coating remains unruptured and evenly deposited. There are appreciable savings in manufacturing, too, because Weirzin sheets and coils require no pickling or buffing, and very little cleaning . . . there is no need for a primer under paint.

WEIRTON STEEL CO.

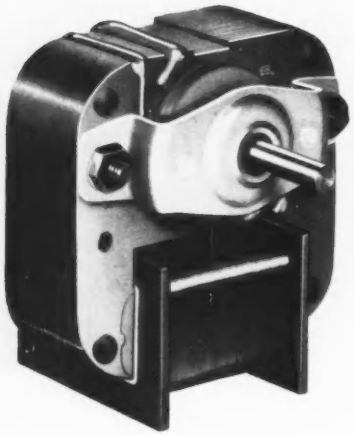
WEIRTON STEEL COMPANY

WEIRTON, W. VA., *Sales Offices in Principal Cities*

Division of **NATIONAL STEEL CORPORATION,** *Executive Offices, Pittsburgh, Pennsylvania*

NATIONAL STEEL

FOR JOBS THAT CALL FOR TOP PERFORMANCE



HERE ARE TWO NEW

Redmond MicroMotors

2-POLE OFFSET MicroMotor

Here's a low cost, skeleton-type Micromotor that is a rugged performer. This 2-pole offset unit is ideal for use in small room heaters, fans, animated displays, and other applications calling for light weight, low power motors. Features include air gap concentricity, sturdy bearing brackets, oil reservoirs packed with felt, and highest quality enameled windings. Two holes in field laminations facilitate mounting. Built in sizes up to 1/100th horsepower.

GEARHEAD MicroMotor

This sturdy, quiet-running gearhead unit is for applications requiring unusual r.p.m. specifications. Output selections are almost without limit down to 2 r.p.m. It is powered by a dependable Redmond 2-pole offset Micromotor with a single bearing lubricated from the gear box. Brake device can be supplied if required. Four mounting holes are provided horizontal to shaft on front surface and four vertical to shaft on base surface.

Redmond COMPANY, INC.

OWOSSO, MICHIGAN

Offices in New York, Chicago, Los Angeles, Dallas

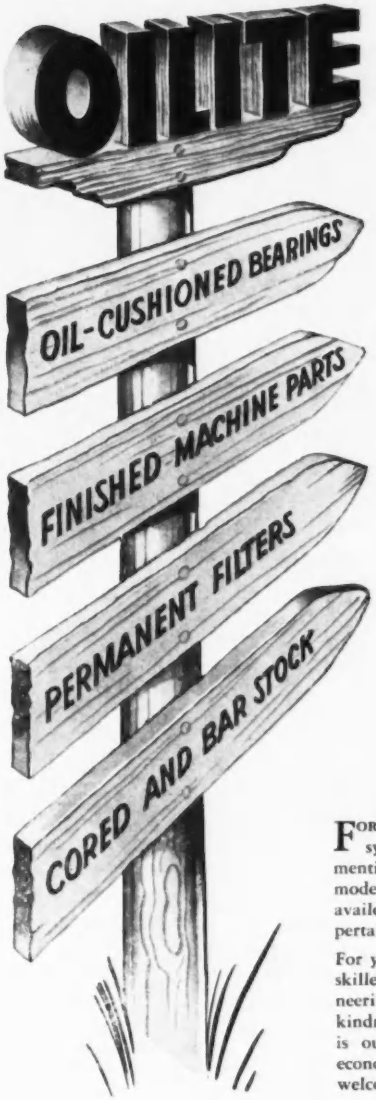
Expanded Facilities • Prompt Deliveries • Service before and beyond the sale

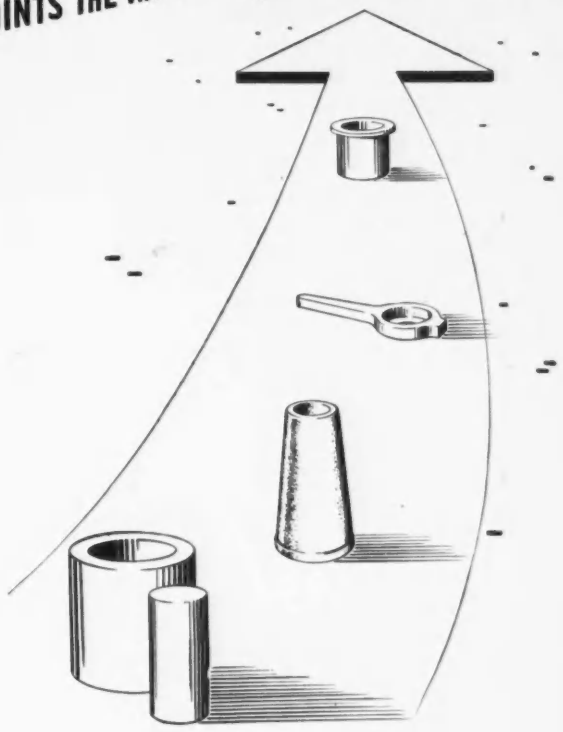
REDMOND

OVER 150 STANDARD MODELS

25 DIFFERENT TYPES

OILITE POINTS THE WAY TO QUALITY





FOR MORE than 20 years many of you have said that to you Oilite is synonymous with *quality*. You have been enthusiastic in complimenting us upon the recent completion of our new plant with its modern equipment and flexible production facilities. Some of you have availed yourselves of Amplex's engineering service other than that pertaining to Oilite Products.

For your kind trust, we are humble and proud. To maintain that trust, skilled Amplex personnel is constantly engaged in the forward engineering of Oil-Cushioned Oilite Bearings, Finished Machine Parts, and kindred products—designed to meet your specific needs. Your objective is our objective—superior products, increased sales appeal, greater economy, and encompassing *service*. Our field and home office engineers welcome the opportunity to work with you.

AMPLEX MANUFACTURING CO.
DIVISION CHRYSLER CORPORATION
DETROIT 31, MICHIGAN

AMPLEX MANUFACTURING CO., 6501 Harper, Detroit 31, Mich.

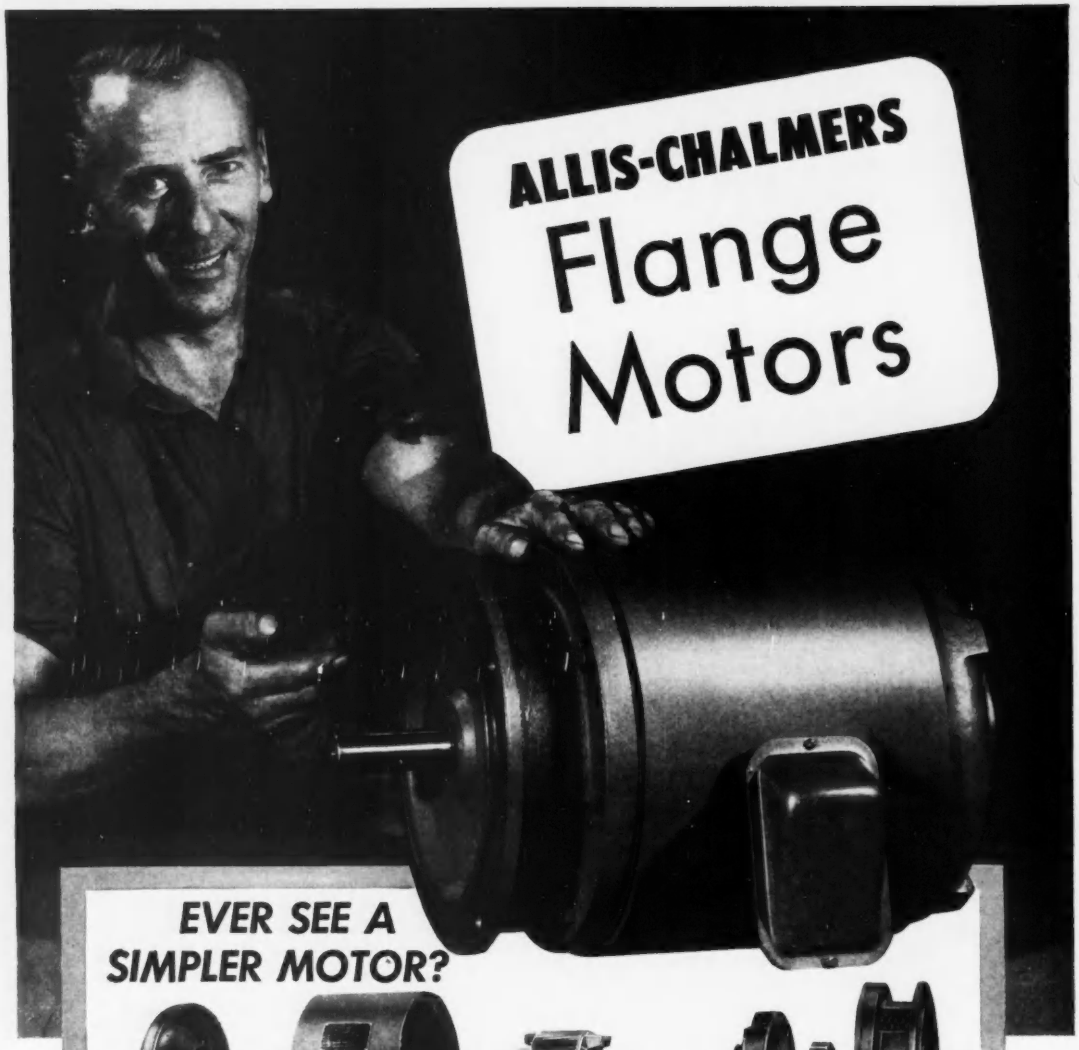
Please send latest information on:

☐ OIL-CUSHIONED BEARINGS ☐ CORED AND BAR STOCK
☐ FINISHED MACHINE PARTS ☐ PERMANENT FILTERS

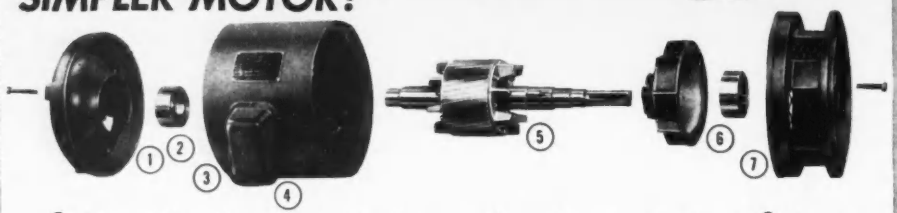
NAME_____

STREET_____

CITY_____ STATE_____



EVER SEE A SIMPLER MOTOR?



① Steel guard directs air stream toward stator windings for efficient cooling. ② Pre-lubricated ball bearings are simple press fit on motor shaft, they require no further lubrication for years. ③ Rigid, cast iron frame completely surrounds and protects stator core. ④ Diagonally-split conduit box is adjustable to any angle . . . is roomy . . . easy to get at. ⑤ Pressure-cast rotor has integrally cast fans . . . no welds or rivets . . . there's nothing to rattle or shake loose. ⑥ Balanced ventilating fan is keyed to rotor shaft . . . produces strong blast of cooling air. ⑦ Flange is counterbored for oil seal . . . has protecting mesh screens.

Sold — Applied — Serviced by Authorized Dealers, Certified Service Shops, and District Offices Throughout U. S.

ALLIS-

GIVE YOUR PRODUCT THIS 4-Point Motor Protection

1. ***Rigid cast iron frame*** completely surrounds all working parts . . . resists corrosion!

2. ***Pre-lubricated bearings*** eliminate bearing maintenance . . . require no further lubrication for years.

3. ***Double-insulation*** gives *extra* protection against heat, moisture, and corrosion.

4. ***Pressure-cast rotor*** has no rivets or welds . . . is indestructible in normal service.

Available in three flange types . . . sizes to 150 hp in open, enclosed and protected types, with electrical and mechanical modifications to suit specific requirements.

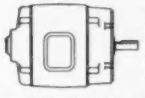
HERE'S A LINE OF FLANGE MOTORS you can design into your products and forget! Notice how *compact* these motors are . . . how *trim* in appearance. Further, their large, roomy conduit boxes and clearly marked connections make them *easy to install.*

Notice how the outer frame completely protects all working parts. This feature combined with pre-lubricated bearings and pressure cast rotors adds up to "all-around" protection against distortion, corrosion, friction and entrance of foreign matter. And bell housing is drip-proof, at no extra cost!

Best of all, these Allis-Chalmers motors are backed by a long-established record for building as tough and sturdy a line of motors as you can find anywhere on the motor market.

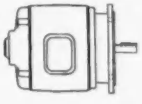
Check your needs in the coupon below for additional information.

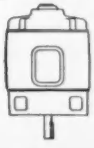
3 TYPES HANDLE MOST OEM JOBS



C FLANGE TYPE — Generally used for close coupling to pumps. Employs rabbet fit with mounting holes on smaller diameter than rabbet fit. Holes tapped for mounting bolts.

D FLANGE TYPE — For machine tool applications. Uses rabbet fit with mounting holes on larger diameter than rabbet. Holes are clearance holes with bolts usually assembled from motor side.



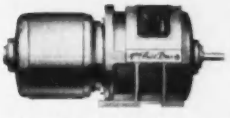


P BASE TYPE — Generally used for vertical applications. Employs rabbet fit with mounting holes on larger diameter than rabbet. Holes are clearance holes.

Texrope is an Allis-Chalmers trademark.

AMERICAN BLOWER GYROL FLUID DRIVES USE ALLIS-CHALMERS MOTORS

New Type TM Gyrol Fluid Drives offer benefits of low starting current, smooth acceleration and shock absorption in the 1 to 20 hp range.



These packaged power drives use Allis-Chalmers constant speed a-c flange motors to produce a smooth start. The motors come up to 85% of full speed before assuming load. Acceleration is gradual and there is a 50% saving in the amount of current consumed for starting. This unit makes overmotoring unnecessary and eliminates shocks to machinery. Overload protection is positive and can be adjusted by changing oil level in the unit. For additional information contact American Blower Corporation, Detroit 2, Michigan.

Check This Coupon

ALLIS-CHALMERS, 1002A SO. 70 ST.
MILWAUKEE, WIS.

Please send me:

- ☐ Flange Motor Specification Sheet (51S7324).
- ☐ Handy Guide to Electric Motors (51B6052).
- ☐ General Purpose Motor Controls (14B7132).
- ☐ Equipment for Machine Tools (25B7110) (Contains information for OEM users on Motors, Texrope drives, Motor Controls, Coolant Pumps.

Name..... Title.....

Company.....

Street.....

City..... State.....

A-2876

CHALMERS

A-C ALLIS-CHALMERS

M=PT . . . BASIC FORMULA FOR DESIGN ENGINEERS

To solve a problem concerning power transmission, apply the formula M = PT (Morse means Power Transmission) and you'll find . . .

1. That Morse Roller Chains and Sprockets are most *easily adaptable* to your specific design needs.

2. That Morse Roller Chain Drives have *extra-long service life* because every phase of their manufacture and assembly is under rigid quality control and precision engineering supervision.

3. That Morse Roller Chain maintenance is *extremely low* due to the use of the finest quality materials in their manufacture.

4. That Morse Roller Chain Drives are *quickly obtainable* from shelf stock. *Ask the Morse Man* from any of the hundred Morse Branch Offices and Distributors. Each is staffed with engineers experienced in every mechanical power-transmission application.

Shaving the face of the earth with a Gargantuan blade is a job that calls for the best and most rugged in power transmission equipment—Morse Roller Chains and Sprockets!

Why Morse Roller Chain Drives Are Specified For The World's Toughest Jobs

For the world's biggest and toughest earth-moving jobs, many road graders and 'dozers now use Morse Roller Chains to transmit power to forward and rear drive wheels. Precision-made, positive-acting Morse Roller Chain Drives are the design engineer's favorite method of transmitting power where *dependability* and long, rugged *service life* come first! When your design calls for roller chain . . . call the nearest Morse Man!

Morse Roller Chains are made in all standard pitches and widths in accordance with specifications approved by the American Standards Association to assure complete interchangeability with all other standard roller chains and sprockets.

ASK the Morse Man nearest you . . . today!

From coast to coast there are more than 100 offices, representatives and distributors of Morse Power Transmission products to give you quick information and service when you want it—where you want it. *Ask the Morse Man first in any case!* Check your classified phone directory under "Power Transmission" or "Chains."

Exploded View of Morse Roller Chain Shows Why It's Specified By Design Engineers

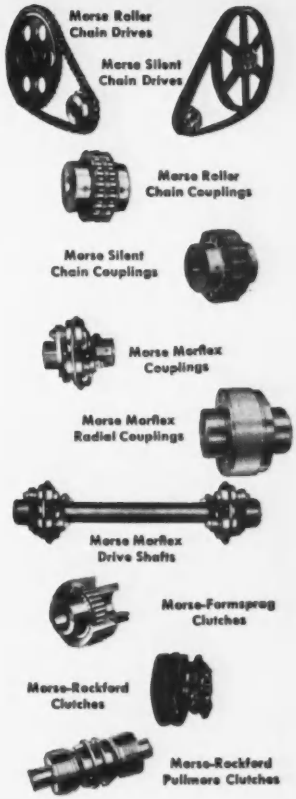
A Morse Roller Chain pins are made from special, high-nickel, fine-grain alloy steel. They are heat-treated and finished for extra strength and extreme resistance to wear.

B Bushings are curled from high-quality alloy steel to give the smoothest possible O.D. and I.D. Smooth inner surface and true roundness eliminates scoring of pins and results in longer life. Bushings are case-hardened.

C Rollers are heat-treated for toughness to provide maximum strength and the greatest possible resilience to shock.

D Plates are heat-treated for structural strength and endurance. Apertures are accurately pierced and sized to provide rigid retention of pins and bushings through proper press fits.

Morse *means* Power Transmission



MORSE
MECHANICAL
POWER TRANSMISSION
PRODUCTS

PRODUCTS OF B-W BORG-WARNER

Morse Chain Company
7601 Central Avenue, Dept. 452
Detroit 8, Michigan

Gentlemen:
Please send me latest technical data and specifications on:

- ☐ Roller Chains and Sprockets
- ☐ Morse Silent and Roller Chain Couplings
- ☐ Morse-Formsprag Clutches
- ☐ Silent Chains and Sprockets
- ☐ Morflex Couplings
- ☐ Morse-Rockford Clutches
- ☐ Pullmore Clutches
- ☐ Have representative call

Name_____

Title_____

Company_____

Address_____

City_____ Zone____ State_____

Have you looked for lower

THE COMPLETE CHAIN BELT LINE

Baldwin-Rex Roller Chains
Baldwin-Rex Double Pitch Roller Chains
Baldwin-Rex CPS Flat Top Chains
Rex Cast & Steel Detachable Chains
Rex Pintle Chains
Rex H-Type Drive Chains
Rex H-Type Conveyor Chains
Rex Refuse & Log Haul Chains
Rex Transfer Chains
Rex Ley Bushed Chains
Rex Combination Chains
Rex Durobar Chains
Rex Cast Roller Chains
Rex Double-Flex Chains
Rex Sugar Mill Chains
Rex Chabelco Steel Chains
Rex Offset Side Bar Roller Chains
Rex Table Top Conveyor Chains
Rex Drop Forged Chains
Rex Drag Chains
Rex Cast Sprockets
Baldwin-Rex Cut Tooth Sprockets
Baldwin-Rex Flexible Coupling
and a complete line of chain attachments.

If you're designing for lower costs, consider these points. Have you thoroughly explored the possibilities for cost reduction and improved performance offered by properly applied power transmission, timing, and conveying equipment?

Perhaps you're using the same basic design . . . the same type equipment for these important functions that has been used for years.

Maybe it's still the best, but you owe it to yourself and your customer to be sure that the product you use is the lowest in cost, consistent with quality and performance.

For example, your design may be overchained. A lighter chain may do the job just as well with important savings to you and the customer. A cast chain instead of a steel chain again may do the job as well at lower cost.

Conversely, your design may be underchained and liable to premature breakdown, resulting in far greater overall cost to you and your customer.

Perhaps you are using other methods of transmitting power or timing operations and a chain drive can effect substantial savings in space, costs and weight.

CHAIN BELT REX COMPANY

CHAIN BELT COMPANY

HERE* *costs?*

There is no one best or stock answer to the problem of transmitting power, timing operations or conveying materials. That is why we at Chain Belt Company feel that we can be of practical assistance to you in designing for lower cost. Because we manufacture a *complete line of chains*, both cast and steel, we can help you select the chain that is exactly right for your machines.

If the operating conditions are such that a cast chain is indicated, we have the exact chain that will best fit the need. Where speeds and horsepower requirements demand a finished steel roller chain, again our complete line contains the answer.

Our Field Engineers plus our Plant Engineers are well equipped to work with you in the selection and application of Rex and Baldwin-Rex Chains for your designs. In many instances they have been able to help effect substantial savings and increase machine efficiency through the flexibility of our complete line and their years of practical experience. Call or write the Chain Belt Company Field Office near you or write direct to Chain Belt Company, 1715 West Bruce Street, Milwaukee 4, Wis.

CHAIN BELT DISTRICT OFFICES

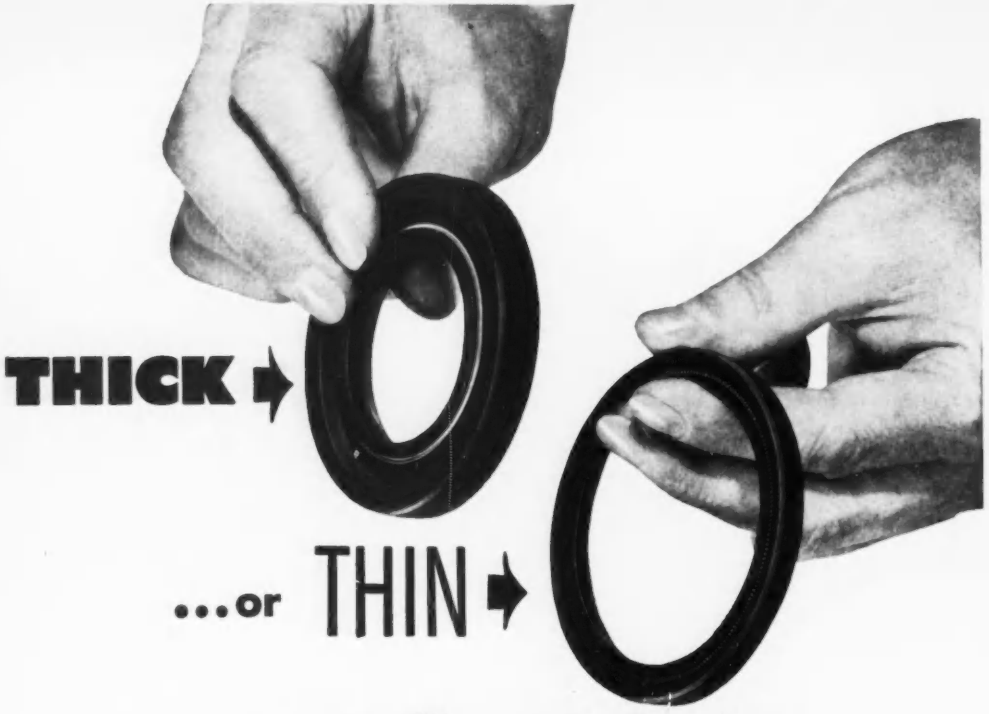
Atlanta	Midland
Birmingham	Milwaukee
Boston	Minneapolis
Buffalo	New York
Chicago	Philadelphia
Cincinnati	Pittsburgh
Cleveland	Portland
Dallas	Richmond
Detroit	Salt Lake City
Houston	St. Louis
Indianapolis	San Francisco
Jacksonville	Seattle
Kansas City	Springfield
Los Angeles	Tulsa
Louisville	Worcester

Here is a composite view of Chain Belt Company's manufacturing facilities. From these plants comes a line of chains unsurpassed for completeness . . . chains that have been serving industry everywhere for over 50 years.

BALDWIN-DUCKWORTH DIVISION
Springfield 2, Massachusetts

REX CHAIN & TRANSMISSION DIVISION
Milwaukee 4, Wisconsin

BALDWIN-REX



...an oil seal design for any cavity

CLIPPER SEALS offer unusual design possibilities . . . and unusual design economies, too.

For example, this new Johns-Manville oil seal is available in flange sections of varying width to fit practically any cavity. In fact, because of the adaptability of its unique one-piece design, there is no cavity mechanically practicable which is too shallow—or too deep—for a Clipper Seal.

Furthermore, because the Clipper Seal has no metal case and is of flexible molded construction, this oil seal permits liberal machining tolerances in the design of the cavity. Its tough, dense outer heel is resilient enough to conform to even a slightly out-of-round cavity. Yet this does not interfere with the seating of the pliable inner lip which always maintains a light, but positive sealing pressure on the shaft for minimum wear.

Clipper Seals are entirely non-metallic, which eliminates the possibility of electrolysis; are available in split and endless types, for sealing against oil, grease, water, air, grit and coolants, in sizes from ¼" I. D. to 66" O. D. If you would like to consult us about a design problem, write Johns-Manville, Box 290, New York 16, N. Y.

Recommended Clipper Seal Flange Sections

Shaft Diameter Inches	Increments	Light		Medium		Heavy	
		Flange Width	Heel Depth	Flange Width	Heel Depth	Flange Width	Heel Depth
⅛ thru 1½	1/16"	¼"	5/16"	5/16"	5/16"	⅜"	7/16"
1 9/16 " 2	1/16"	9/16"	5/16"	⅜"	7/16"	½"	7/16"
2⅛ " 2⅞	⅛"	9/16"	5/16"	⅜"	7/16"	½"	7/16"
3 " 5⅞	⅛"	⅜"	7/16"	½"	7/16"	⅝"	⅝"
6 " 9⅞	⅛"	½"	7/16"	⅝"	⅝"	¾"	⅝"
10 " 19¾	¼"	⅝"	⅝"	¾"	⅝"	1"	⅞"
20 " 29¾	¼"	¾"	⅝"	1"	⅞"	1¼"	⅞"
30 " 36	¼"	1"	⅞"	1¼"	⅞"		

Recommended dimensions for shaft diameters from ¼" to ⅛" and over 36" on request.

Johns-Manville **PACKINGS & GASKETS**

"Clean As A Whistle"
TO MAKE and TO USE

...and you can say that of any vac built with American Phillips Screws

CLEANER PRODUCTION: No scarred parts, no slashed hands, no floors littered by fumbled screws. For when an American Phillips Screw is put on the point of its 4-winged driver ... then they become one straightline unit until the recessed screwhead is turned up flush and tight ... the *first* time, *every* time. Saves rejects, saves screws, *saves time up to 50% over out-of-date slotted screws.*

CLEANER SALES: Buyers of modern, top-quality products know the buy-sign of the universal Phillips crossed recess on everything from their automobiles to their golf clubs. To them, the Phillips recess means that when a product is so put together, *it stays put.* To you, it means fewer returns and fewer free servicings, especially where vibration is involved. So remember, from both viewpoints ... production and sales ... *American Phillips Screws always cost least to use.*

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4-WINGED DRIVER CAN'T SLIP OUT OF PHILLIPS TAPERED RECESS

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

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Bearings exposed to excessive dirt, dust or other foreign matter need the protection which Federal Felt-Labyrinth Seals provide. This combination seal—which is equally effective with either ring revolving—consists of a woven felt between two steel washers, one spun into a groove in the outer ring and the other secured to the inner.

Federal Single Row Radial Felt-Labyrinth Seal Ball Bearings are engineered to take combined radial and thrust loads as well as provide maximum sealing efficiency. Manufactured in three series—single seal, double seal and single seal with metal shield on undercut side—each has the tolerances and load ratings of Federal Single Row Radial Bearings.

In our catalog "K" you'll find descriptions of these and all other bearings in the Federal line—in every type and size—for every anti-friction need. Among the 100 pages of engineering data are ball bearing selection charts to help you compute bearing loads, determine load ratings at all speeds, and select the right type and size bearing your individual application requires.

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COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by BRIDGEPORT BRASS COMPANY "Bridgeport" *Headquarters for BRASS, BRONZE and COPPER*

Brass and Phosphor Bronze for Pressure Gauges

Highly corrosion-resistant copper-base alloys are the backbone of pressure gauges designed for air, water, steam, oil and other media.

Accurate readings, despite constant fluctuations, vibration and corrosive conditions, are essential in gauges made by the Jas. P. Marsh Corp., Skokie, Ill., shown below.

Phosphor Bronze

The heart of the pressure gauge is the curved bourdon tube of phosphor bronze. It is elliptical in shape and the physical properties of the bronze and the dimensional accuracy of the completed tube are very critical.

As pressure is applied inside the bourdon tube it tends to straighten out from its 270° arc. The amount of motion is transmitted to the pointer, which moves over a calibrated scale and indicates the applied pressure. The temper and spring characteristics of the metal prevent it from becoming "set". Any change in its physical characteristics or corrosive attack would immediately affect the accuracy of the gauge.

The movement actuated by the bourdon tube consists of socket, plates, rack, studs, pivot shafts, pinion gear, hair spring, bushings, linking arm, and closing end for the tube. All but the pinion and shafts are brass or bronze.

The bourdon tube is linked to the gear segment, which is also made of phosphor bronze. Resistance to wear, fatigue and corrosion are as important as extreme accuracy. It must also withstand a wide range of temperatures with minimum distortion.

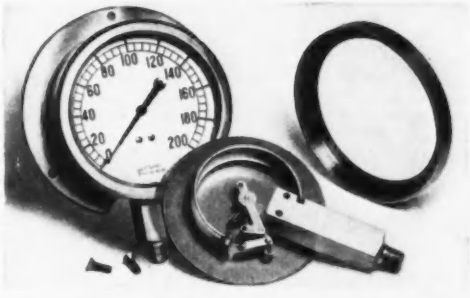
Phosphor bronze, known for its fatigue resistance, is also used for the hair spring which takes backlash out of the rack and pinion assembly. Phosphor bronze bushings are found in the plates for all shafting.

Leaded Brass for Ease of Machining

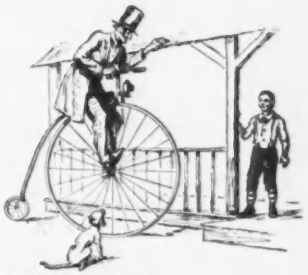
The plates, blanked, pierced, drilled, reamed and tapped, are made of clock brass containing lead for ease of blanking and free machinability.

The socket, into which the bourdon tube is mounted and on which the movement is attached, is square, extruded free-machining brass rod. Drilling, turning, milling and tapping is done at great speeds on this leaded alloy.

The selection of the correct material for all types of products can be simplified by contacting the nearest district office or Bridgeport Brass for information. Machining, corrosion and other problems are met daily by the men in our laboratory and behind them are many years experience in producing quality copper-base alloys.



Phosphor Bronze and Brass are used for vital parts of pressure gauge. Courtesy Jas. P. Marsh Corporation.



Did You Know... Bridgeport Brass Made Bicycle Lamps?

Previous to the introduction of the "Safety Bicycle" in the late 80's, Bridgeport developed the first successful bicycle lamp operated with coal oil. Its "Searchlight Bicycle Lamp" was exhibited at the Chicago World's Fair in 1893.

The 'cycle illustrated above was available only to the well-to-do because of its high cost. Also, considerable skill was required to prevent injury from serious falls. Then came the "safety" which closely resembles the modern bicycle except that solid rubber tires were first used.

With the development of pneumatic tires, the Age of Speed was born. Tandems, bloomers and century runs became the main topics of conversation. And raised eyebrows followed the radical bloomer girls in those good old days.

The bicycle, in some measure, helped to improve the highways. A three-foot asphalt bicycle path along the edge of dirt country roads made for smoother riding. The bicycle paths disappeared when the automobile called for the modern concrete and asphalt roadbeds.

Bright burning acetylene lamps soon replaced the kerosene bicycle lamps. Other items such as bicycle bells and pumps or tire inflators rounded out the Bridgeport line of sporting goods.

BRASS · BRONZE · COPPER · DURONZE — STRIP · ROD · WIRE · TUBING

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BRIDGEPORT BRASS COMPANY
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Established 1865
"Bridgeport" *District Offices and Warehouses in Principal Cities*

When You Want New Ways to Reduce MACHINING COSTS ON STAINLESS JOBS

—use this *Carpenter* help!

NO MORE COSTLY HAND WORK...

Excessive burring during machining caused rejects, or expensive hand work to "salvage" the parts from the scrap heap. Because of the change to Carpenter Free-Machining Stainless, the burring problem disappeared and fishing reel parts are produced faster, at less cost.

You Can Turn It Out AT LESS COST with Carpenter Free-Machining Stainless!

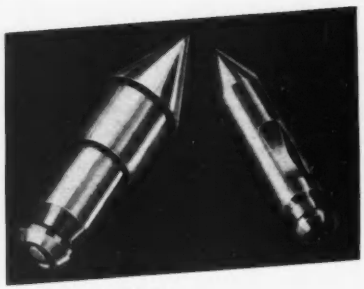
The cost of the steel you buy is only a fraction of the cost of the finished products made from Stainless. To get a lower *unit* cost for every Stainless part you make, take advantage of the help that Carpenter can give you.

Our help starts with the *uniformity* of the free-machining Stainless you buy from your Carpenter warehouse. Every lot machines the same, to the finish you want.

Next, Carpenter's STAINLESS MACHINING "NOTEBOOK" gives correct information on speeds, feeds and tooling, etc.... and Check Charts that list common "trouble spots" with shop tips on how to cure them. For your NOTEBOOK, send us a note on your company letterhead, indicating your title, please. Extra copies of the NOTEBOOK, for the men in your shop, are available at 50¢ each.

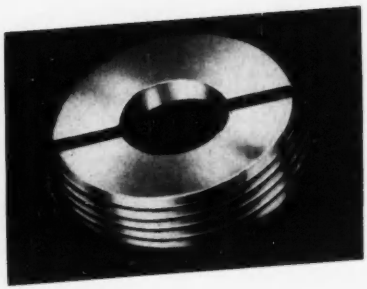
Using Carpenter's SHOP HELP ON NEW JOBS is another way to bring down the cost of working with Stainless, where special requirements or close tolerances are important. Combine your nearby Carpenter representative's experience with easy-to-work Carpenter Stainless bars, and you have a large part of the answer to low cost machining on your Stainless jobs. Get in touch with the nearest office listed below.

THE CARPENTER STEEL COMPANY, 117 West Bern Street, Reading, Pa.



MORE PARTS PER DAY...

Actual time records show an increased number of parts per day, flawless finishes and longer tool life now that Carpenter Stainless No. 8 (Type 303) is used for these corrosion-resistant valve needles.



UNIT COST: 5¢

Production slow—rejects excessive and unit costs "impossible" until Carpenter Stainless No. 8 (Type 304) was used for making this bearing race. Unit cost is now only 5¢... tool life has more than doubled and rejects have dropped 40%.

Export Department: 233 Broadway
New York 7, N.Y. "CARSTEELCO"

Carpenter

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STAINLESS STEELS

When You Want *Rush* Delivery Call Your *Carpenter* Warehouse—

more than corrosion resistance

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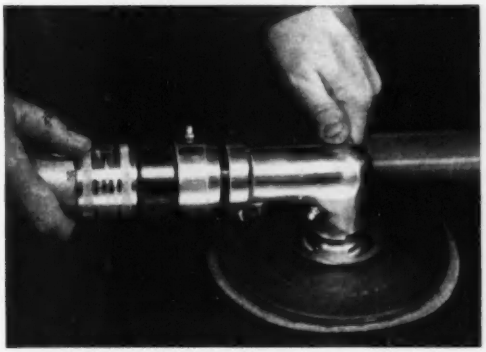
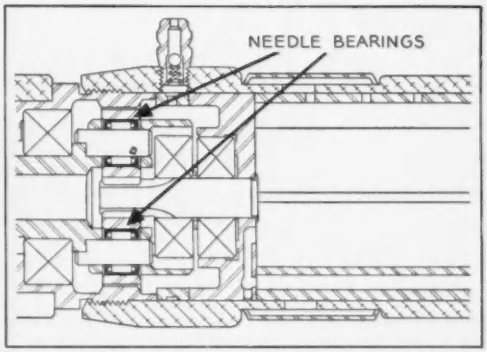
CHICAGO	DETROIT	NEW YORK	WORCESTER, MASS.

SEE THE CLASSIFIED SECTION OF YOUR TELEPHONE DIRECTORY

Torrington Needle Bearings Increase Power Output 10% in ARO Pneumatic Tools

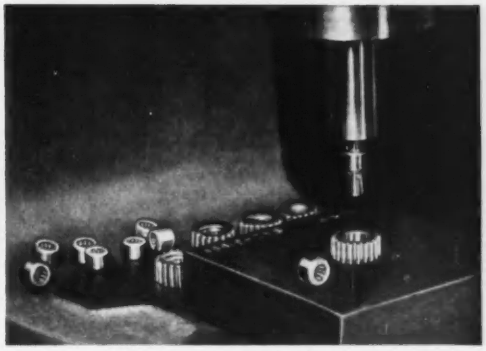


By Applying Torrington Needle Bearings in the planetary gears of the Model 7099 Screwdriver and Model 7095 Sander, Aro Equipment Corporation, Bryan, Ohio, increased power output 10%. This increase in efficiency, determined by special tests, is accompanied by reduced lubrication and maintenance, and longer service life.



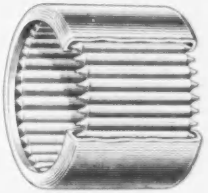
No Major Design Changes were needed to adapt Needle Bearings to this application, shown above in cross-section. These compact anti-friction units met the space and weight limitations ideally, with no sacrifice of reliability. The full complement of small diameter rollers assures tremendous radial capacity.

Service Life Tests were run for as much as ten times the normal life of the tools. Previously, the planetary gears, shown above, had been a trouble spot – but the Needle Bearings and the pins that serve as shafts showed no appreciable wear when tests were completed.



Installation of the Bearings is a simple arbor press operation. Lubrication is greatly simplified, since the turned-in lips of the shell of Needle Bearings retain an ample reserve of lubricant. With wear reduced to a minimum, savings in maintenance may run as high as 20 to 1, according to the manufacturer's experience.

This case shows how the performance, lubrication and service life of *your* equipment can be improved by a simple change to Torrington Needle Bearings. Let our engineers help you adapt them to your needs. Write us today. THE TORRINGTON COMPANY, Torrington, Conn., or South Bend 21, Ind. District offices and distributors in principal cities of United States and Canada.



TORRINGTON *NEEDLE* **BEARINGS**

Needle • Spherical Roller • Tapered Roller

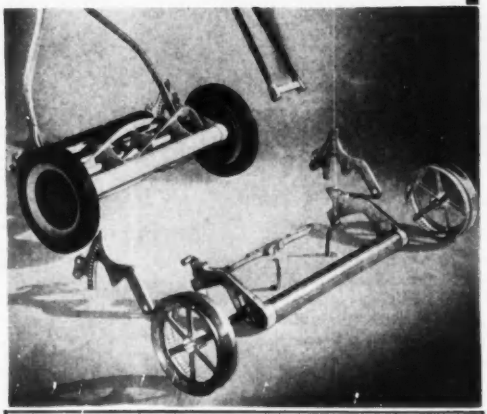
Straight Roller • Ball • Needle Rollers

STRENGTH!

DIE CASTINGS OF ZINC ARE TOUGHER THAN THOSE OF OTHER COMMONLY DIE CAST METALS

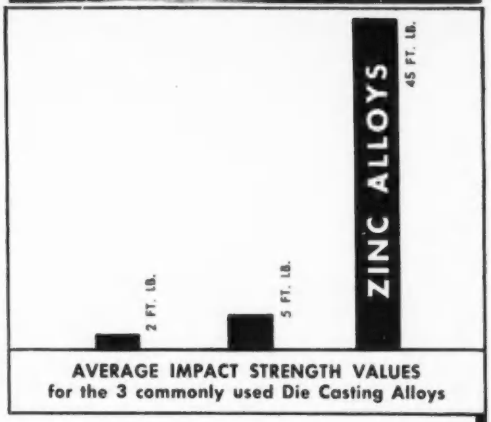
RUGGED SERVICE

The choice of ZINC die castings for the wheels, side frames and other parts of this lawn mower is the result of 10 years of performance in earlier models. Rocks, twigs, sand, trees and other obstructions are all in the day's work for this mower —thanks to *tough* ZINC die castings. If abusive handling in service is a factor to be reckoned with in designing *your* products, consider the excellent strength characteristics of this modern metal and method of fabrication.



SHOCK RESISTANCE

The ability of ZINC die castings to resist sudden shock, in comparison with die castings of the other commonly used metals, is graphically shown at the right. And shock resistance—technically known as impact strength—is only one of the strength characteristics in which ZINC excels. It is also superior in tensile and compressive strength, as well as in ductility and hardness. In short, ZINC die castings get the call where toughness is required.



AVERAGE IMPACT STRENGTH VALUES
for the 3 commonly used Die Casting Alloys

High strength is just one of the many advantages which make ZINC die castings the most widely used. Every die casting company is equipped to make ZINC die castings and will be glad to discuss these advantages with you. Or write to us.

The New Jersey Zinc Company, 160 Front Street, New York 7, N. Y.

ZINC
FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

No Substitute for Good Leadership

An army of stags led by a lion would be better than an army of lions led by a stag.—EARLY LATIN PROVERB

WE BORROW from the French and call it Esprit de Corps or Morale. It is also pride, enthusiasm, or unity of purpose. Call it by any name, there is a spirit of harmony in any good organization that is as obvious as the black ink on the company books, and just as important.

Just as men in armies have seen disorganized, rebellious groups of men turned into an efficient fighting outfit by one good leader, so men in every industry have seen leaders turn a group of dissatisfied and disgruntled workers into efficient producers.

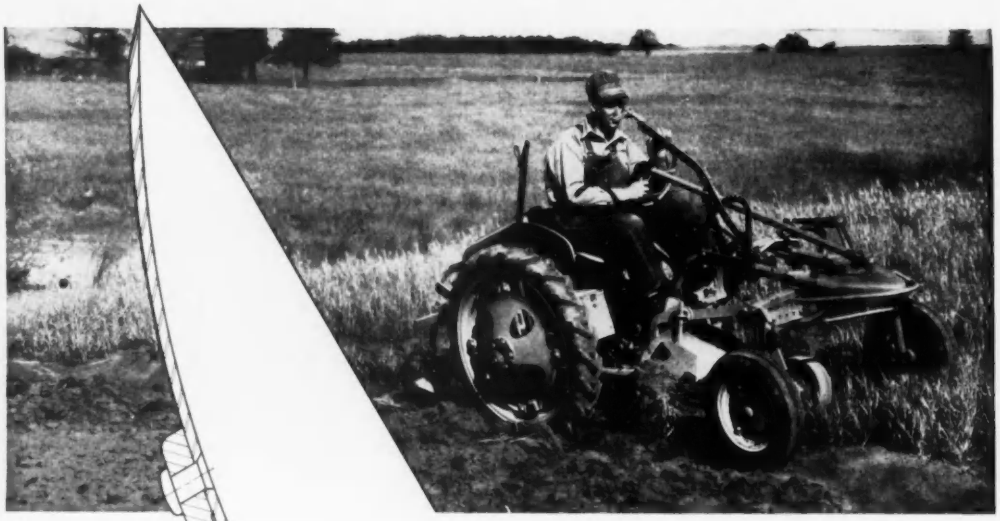
We are told that leaders are born, not made. If this is true, then honesty, fairness, and insight are all qualities given to a chosen few at birth. We do not believe this to be true. A true boss does not push, but leads. He does not shout, but explains and knows whereof he speaks. He gives criticism where criticism is due, but does not underrate or damn with faint praise. A man who measures up to the high standards of leadership does so because he has long known and respected the human race. He is no more born with qualities of leadership than with a knowledge of mathematics.

We hear a lot today about good working conditions, wage increases, pension plans, vacation plans, new lighting schemes, new decorative effects, and a multitude of other such cure-alls designed to increase worker happiness and efficiency. These schemes are helpful and important to the organization—just as more money, a better house, and new clothes, are important to a family. They don't, however, insure a contented, efficient organization. Just as in families, industrial organizations are built on the human equation. Any attempts to substitute pleasant sugar pills for the human virtues of respect, fairness, and discipline are futile.

Good leadership is the ingredient that turns a group into an organization, and the organization derives its own peculiar personality directly from its leader.

G. F. Zodenholtz

WHERE 1+0=TWO



The preloaded Double Row Angular Contact ball bearing originated and perfected by New Departure is noted for its ability to resist radial, thrust or combined loads from any direction, and for its extreme resistance to deflection under cocking or misaligning loads.

As a result, this bearing is used with outstanding success in many applications to take the place of two bearings spaced apart.

In the Allis-Chalmers Model G One and Two-Way Disc Plows, one bearing supports each disc and assures the necessary rigidity, yet with complete freedom of rotation. No bearing adjustments of any kind are required.

The New Departure Double Row bearing is also available with shields and with snap ring on the outer ring for axial location without inside housing shoulders.

Nothing Rolls Like a Ball

NEW DEPARTURE
BALL BEARINGS

80

NEW DEPARTURE • Division of GENERAL MOTORS CORPORATION • BRISTOL, CONNECTICUT • BRANCHES IN ALL PRINCIPAL CITIES

The Commonwealth Engineering Company of Ohio

DETERMINING THE TORQUE, power and efficiency of a gear type hydraulic motor. Gear motor is supplied with oil under pressure from the radial variable delivery pump. The load is a gear pump directly connected to the shaft of hydraulic motor.

Research in Industrial Hydraulics

A plan to provide for more basic research projects that will furnish design data much needed in the field of industrial hydraulics. The discussion covers research that is needed to answer constantly recurring questions that arise in connection with education for research, the qualifications of personnel, cost of equipment and research activity, and who should do the research.

WARREN E. WILSON
President, South Dakota School of Mines and Technology

RESEARCH is a scientific search for facts. At first sight, some difficulty may occur in reconciling this definition with the commonly accepted ideas that consider research to include not only the search for basic facts but also the process of invention and development. One may reconcile the two, however, if he accepts the concept that neither invention nor development is research unless an improvement is evolved based upon a newly discovered fact and that has been obtained by a scientific study of the problems encountered.

Since research is the search for facts, one may safely conclude that it is needed in any field so long as unanswered questions still exist in that field. Conversely, research is not needed if a single source of information exists that can supply all the answers to all the questions that may be asked about any particular subject. On this basis, there is without doubt a great need for research in industrial hydraulics as well as in all other fields of activity.

For the purposes of this discussion industrial hydraulics is considered to be that branch of the broad field of hydraulics concerned with the positive displacement pump and motor and the controls for these two machines. The positive displacement hydraulic transmission obviously is included in this category.

The history of positive displacement hydraulics extends back to the eighteenth century. Then, Joseph Bramah perfected a means of securing a tight fitting piston that would operate in a cylinder, thus making possible the development of high pressures by means of a reciprocating pump. Following this invention hydraulic applications developed rapidly. By the middle of the nineteenth century, following the invention of the accumulator, the city of London was piped for hydraulic power transmission.

In 1873, Hastie patented a variable stroke pump. In retrospect, it appears that it should then have been possible to construct a variable speed transmission, making use of a pump and motor in combination, thus dispensing with the accumulator. This arrangement was not accomplished and hydraulic power fell out of favor. It was not until 1922 that a large scale revival of the use of hydraulic power was signalled by the introduction of the hydraulic broaching machine.

The initial development of the mul-

The Commonwealth Engineering Company of Ohio

RUNNING A PERFORMANCE TEST on a hydraulic gear pump to determine its characteristics. Tests are run using fluids of different viscosities and densities.

tiple plunger variable stroke pump started about 1890. This pump was used for a number of applications outside of the industrial power transmission applications under consideration here.

Research in industrial hydraulics has been largely invention and development as differentiated from basic fact finding. It is doubtful that any line of activity has seen the application of more ingenuity and effort to the development of patentable devices that differ only in some mechanical detail. One is tempted to believe that every possible positive displacement mechanism has been patented or at least sketched.

Positive displacement pumps and motors are obviously mechanical devices that produce hydraulic forces or are driven by them. This combination requires that the engineering designer be familiar with mechanical design in order to proportion properly the physical elements in accordance with their mechanical function. In addition he must have some knowledge of the mechanics of fluids in order to determine the hydraulic forces acting and to investigate the flow of the liquid through these devices.

One difficulty in the past has been that most mechanical engineers were quite familiar with mechanical design; that is, statics, dynamics, strength of materials, mechanisms and kinematics; but lacked basic education in fluid mechanics. The positive displacement pump and motor, therefore, were naturally designed almost entirely as mechanical devices. In fact, the proportion of development work done in this field by men who were not technically trained engineers, but rather had a flair for mechanical gadgetry, is extraordinarily high.

The application of the science of fluid mechanics to the solution of the problems of the industry came largely from the pressure of the requirements for aviation, especially during the war years. The time has been too short and the amount of activity too limited, however, to have yielded more than a sample of what can be done.

Research activity of any group, or in any particular line of work, may be generally measured by the quantity and quality of the technical publications in the field in question. A survey made five years ago, of the literature of positive displacement hydraulics revealed that very little had been written about the subject. As far as could be learned from what had been set down, little or no basic research had been done. For example, nowhere in the literature was it possible to find answers to the following questions:

1. What is the proper viscosity of an oil to use in a hydraulic transmission, the performance characteristics of which must meet a particular specification?
2. What is the proper clearance to use between the gears and housing of a gear pump that is to pump oil of a particular viscosity at a specified pressure and speed?
3. What is the effect of inlet design on the performance of a piston pump at high altitudes?

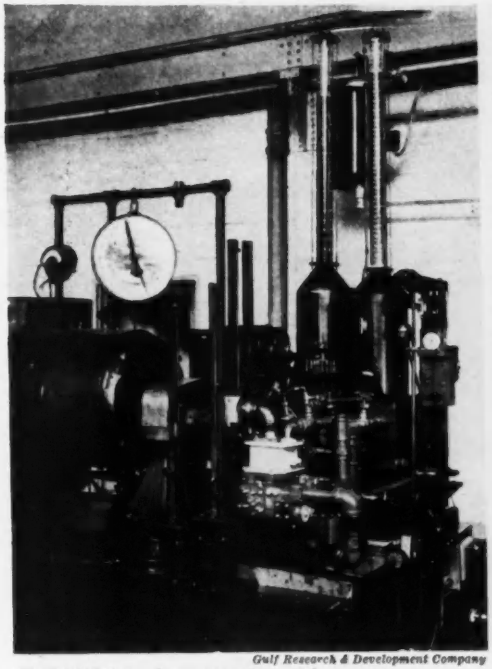
As a result of this paucity of technical literature the young design engineer is placed in a difficult position. His textbooks on mechanical design probably mention the existence of the positive displacement pump, but give no clues to the critical factors in the design. He can find no book devoted specifically to the problems of the design of such devices. The current periodical literature contains little if any factual information. He is forced therefore to rely upon the time honored methods of his predecessors, that is, cut and try designing and testing.

Lack of research is also evident in the products themselves and in the sales literature accompanying them. Each pump and motor is usually sold for use with a particular oil. Their performance is described in terms of a constant speed at various pressures. The user is cautioned concerning the performance to be expected under conditions of operation other than those specified. Either from the sales literature or discussion it is difficult, if not impossible, to get a clear picture concerning the performance to be expected under any specified conditions.

The application of hydraulic devices to servomechanisms required that many facts, never before considered, be learned and evaluated. This application grew apace during the war and resulted in the strange situation, wherein experts in electrical engineering did some of the best and most advanced thinking in hydraulic control research.

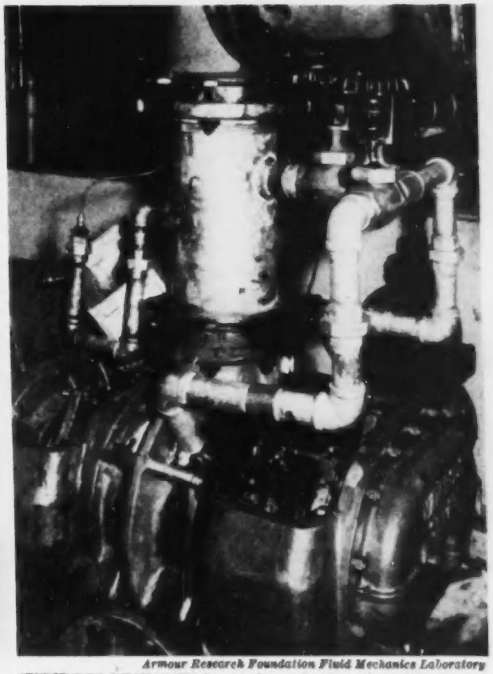
General Research

With reference to general research requirements, one immediately and naturally draws the conclusion that it is necessary to establish a means of describing the performance of the product and of obtaining the experimental data for the purpose. Strangely enough, testing programs throughout the industry are extensive and many data are available, but a widely adopted



Gulf Research & Development Company

TEST SETUP for determining the perfofmance of an aeronautical lubrication pump with known percentages of entrained air.



Armour Research Foundation Fluid Mechanics Laboratory

SETUP FOR RESEARCH for the determination of possible sources of cavitation noise in a large size positive displacement pump.

system for their presentation is still lacking. Once a wholly satisfactory method of gathering and presenting data is adopted, the actual taking of the factual material can no longer be considered research but rather routine testing.

Further consideration leads to the conclusion that research is required whenever the necessity arises to go beyond the readily available factual data to answer a question concerning the product, its design, production or performance.

Research can, of course, be any one of several types, namely, experimental, mathematical, literary or combinations of these. Generally speaking when one is looking for an answer to a problem, he should first consult the literature. If the answer is not in the literature, resort to mathematical analysis using available facts as the basis of the study may be necessary. Failing to obtain the desired result in this manner one must resort to direct experimental determination of the desired information.

A representative sample of the current questions asked by the designer of positive displacement pumps and motors, and found answered unsatisfactorily if at all, are:

1. What causes noise in a gear pump and how may it be avoided?

2. Having given the viscosity of the liquid, the speed and pressure, what is the optimum clearance for a pump or motor?

3. What are the properties of the ideal hydraulic liquid?

4. What forces and torques are required to operate a given control mechanism, that is, to change the angle of inclination of a swash plate of a piston motor?

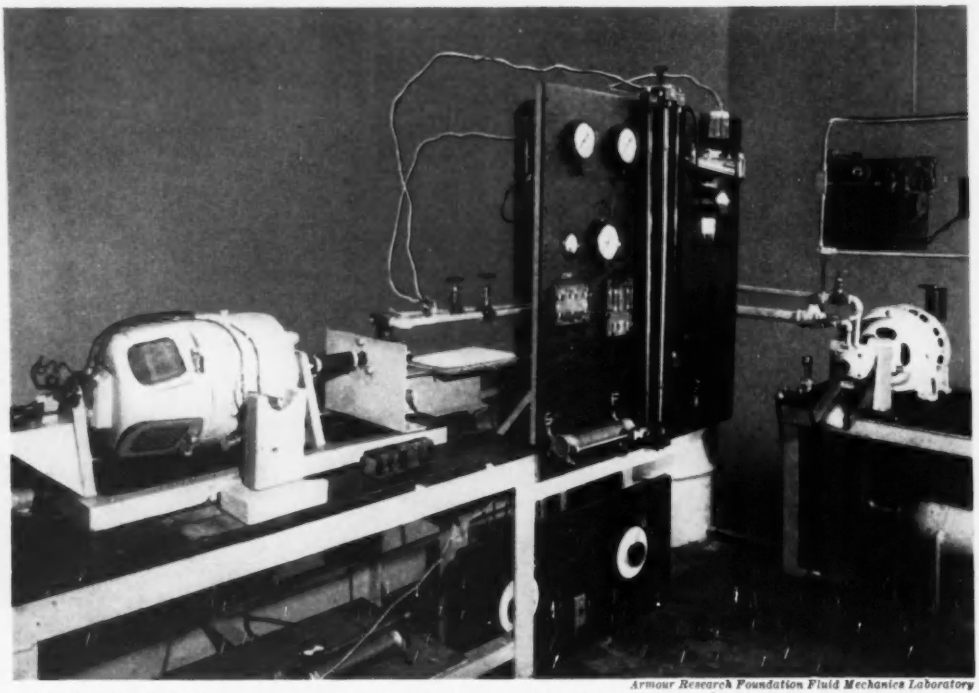
5. What will be the response rate of a given control mechanism?

For each of these questions some factual information is available that is of assistance in formulating an answer. Some engineers feel that they have a sufficiently good answer available upon which to base their design. Further, a small group of men exist who are sure that they know the answers to all the questions, but feel they must maintain strict secrecy. The following discussion, it is hoped, may serve to point the way to a possible means of securing answers to these and other similar questions that continually plague the designer.

Noise in all pumps can usually be traced to one or more of several causes, two of which are outstanding. First, trapping of the liquid; and second, cavitation. Yet frequently, even after everything has been done to remove these two causes of noise, an objectionable noise level remains. Basic research directed towards the determination of the cause of noise in any type of positive displacement pump is indicated. But such a program is a long time project that is costly in terms of both manpower and equipment.

The problem of selecting proper clearances is one that has always confronted the designer. The writer's research on this topic points the way towards a solution but, being based on the assumption of a liquid of constant viscosity, must be considered as a first approximation only. A program pointed toward the determination of the effect of change in viscosity of the liquid within the pump must be carried through before the final answer is available. This project also is a long time one and expensive.

To guide the research activities of the oil and synthetic liquid industries, the properties of the ideal hydraulic liquid must be defined. The effect of variation in viscosity on performance must be established, and the importance of a liquid of constant viscosity evaluated. Since the undesirable effects of entrained air are understood rea-



Armour Research Foundation Fluid Mechanics Laboratory

LABORATORY SETUP for conducting research on the performance of small hydraulic motors under simulated service conditions.

sonably well, the definition of the ideal hydraulic liquid should include a limitation on the amount of air that is permissible.

Calculation of the forces and moments required to actuate control mechanisms is not always straight forward. Considerable analytical investigation and much checking by experimental means are necessary before one can describe, in elementary terms, the methods to be used in calculating the significant constants and variables needed in analyzing the transient behavior of a hydraulic servomechanism. In this case, the need is largely for engineers who are well educated in the use of mathematics and theoretical mechanics.

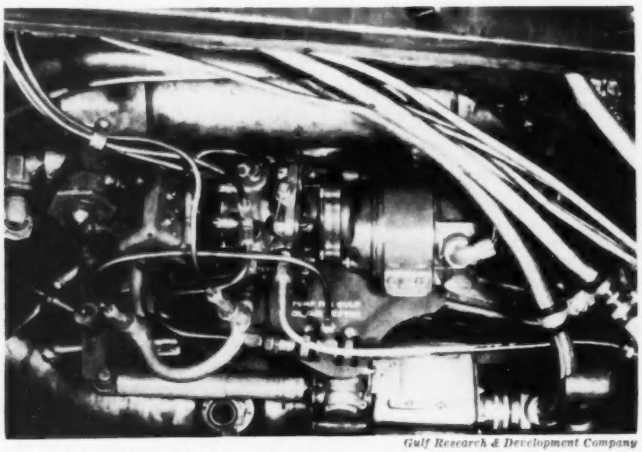
Calculation of response rates, and the determination of the stability of a hydraulic control system, require knowledge of the items discussed in the preceding paragraph, as well as familiarity with the recent developments in the analytical methods used in servomechanism studies.

Manpower Requirements

The qualifications required of research personnel are more greatly misunderstood than those for any other part of research in this field. Primarily, the research man must be highly intelligent. In addition, he must have the analytical type of mind. He need not be either an inventor or a designer.

Frequently the inventive genius, who is the backbone of some of the smaller companies in the industry, is called the research engineer. Too often he has never heard of the scientific method. The controlled experiment is as foreign to his technique as his automatic machinery is to the work of the Chinese coolie.

As has been pointed out, the posi-



Gulf Research & Development Company

PUMP AND TESTING INSTRUMENT for measuring and indicating the percentage of air that is entrained in the oil in an aeronautical lubrication system.

tive displacement machine is a hydromechanical unit, the design of which overlaps at least two fields. Consequently, the research man must be familiar with the basic science underlying both mechanical and hydraulic design.

Probably the best education for industrial hydraulic research is a thorough grounding in: Mathematics including at least differential equations; mechanics including elasticity, hydrodynamics and advanced dynamics with particular emphasis on stability. Whether the man's education be basically in engineering or physics is not too important. If he has majored in physics, he will need to study production methods and problems on his own. If in engineering, he will probably find refreshing in mathematics to be necessary.

An invaluable asset should be developed by this man, that is, the ability to interpret the results of his research in terms understandable to the design and production engineers, whose interest in mathematics is nil and whose driving motive is to get the design into production.

Equipment

For a research program, the equipment necessary depends entirely upon the nature of the problems to be investigated. More important in many ways than the type of equipment is the availability of the equipment for research. Since it is difficult to realize the value of an expensive piece of equipment that may be idle much of the time, for research studies generally are infrequent, the tendency is to assign routine test equipment for research.

Such a procedure keeps the equipment in use but practically destroys its usefulness for research, which must be unhurried in its execution. It must be realized that in research more time, effort and money are spent in preparing to make a measurement, and in determining its significance after it is made, than in making the measurement itself. There is absolutely no point in gathering masses of data if the interpretation is not made, or worse still if it is incorrectly made.

That research equipment in this field of activity is expensive, goes without saying. Dynamometers, fluid flow meters, photographic and electronic equipment are indispensable and all are costly. No research program, however, can be carried on without proper measuring instruments. No theoretical or mathematical analysis can be considered completely useful until checked in the laboratory.

Cost of Research

With reference to the cost of research not too much of significance will be said, but that which will be set forth here can be useful when properly interpreted. In general, one may say that every element of research is expensive. Certainly the equipment is costly both item by item and in the aggregate. When proper manpower is selected it must be well paid. Housing and servicing the research group requires expenditures of considerable magnitude. On a percentage basis and in terms of results obtained, however, the picture is entirely different.

Generally, it is agreed that an industry of any considerable size can maintain an adequate research program with an expenditure of two percent of gross sales for research provided, of course, that there is not some very unusual factor to be considered. In the industrial hydraulics field, where so much research must be done and many of the companies are small, the financing of research on an adequate scale presents a difficult problem.

Who Will Do the Research

Much of the research to be done in industrial hydraulics is of a basic nature and cannot be expected to yield results that will bring in sales dollars within the same year, perhaps not in the same decade. To expect a small company to finance such a program is out of the question. In addition to the cost of the program, one must consider the fact that the results will be useful to all members of the industry, hence any one company is reluctant to embark on such a costly venture knowing that eventually and inevitably the results will be shared with competitors.

Then the research must be done either by the large companies, engineering colleges, research institutes or government agencies. A company is large in terms of research, if it can justify spending for research an arbitrary sum of two percent of gross sales, and if this two percent provides an adequate sum for basic research.

A company doing a million dollar business, for example, would be justified in spending twenty thousand dollars per year on research. This sum is definitely not enough to permit basic

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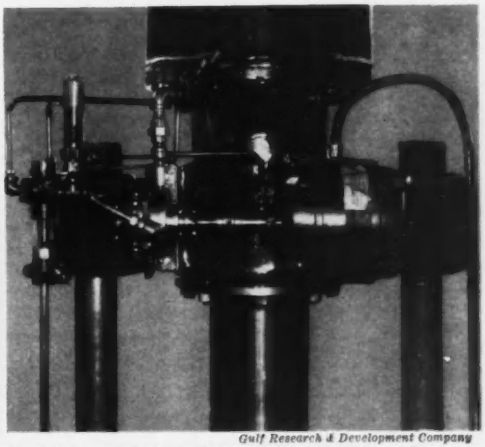
CONDUCTING TESTS on viscous fluid flow through narrow passages for compilation of data at different rates of flow.



Gulf Research & Development Company

POSITIVE DISPLACEMENT GEAR PUMP mounted on an hydraulic press to achieve an overall compactness in design.

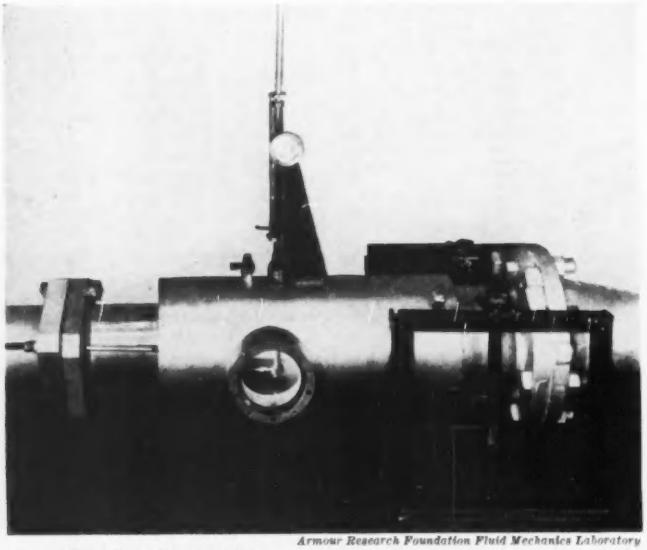
research. But a ten million dollar business could finance two hundred thousand dollars in research and could well afford ten percent of that for basic work. It is almost axiomatic that little can be done in a research program requiring any considerable amount of experimental work for less than ten or twenty thousand dollars per year. Consequently, a company doing less than five million dollars worth of business a year cannot be expected to do basic research. A study of the industry reveals that there are many small companies and very few large ones, hence one can expect little from the industry in solving its basic problems.

A program of basic research sponsored jointly by a group of companies would be a great aid in solving many of the basic problems of the industry. Such a program could be carried out at a college or industrial research institute. There is no indication, however, that the present moment is opportune for such a venture.

Basic research on a fellowship basis at an engineering college is another possible solution to the problem. The advantage of such an arrangement is relatively low cost. It also provides for the education of a young engineer, who before completing his academic work and becoming available for work in the industry will be familiar with some of its problems. Small companies can finance this type of work and thus solve their research problems. At the same time, they will be building up their engineering personnel.

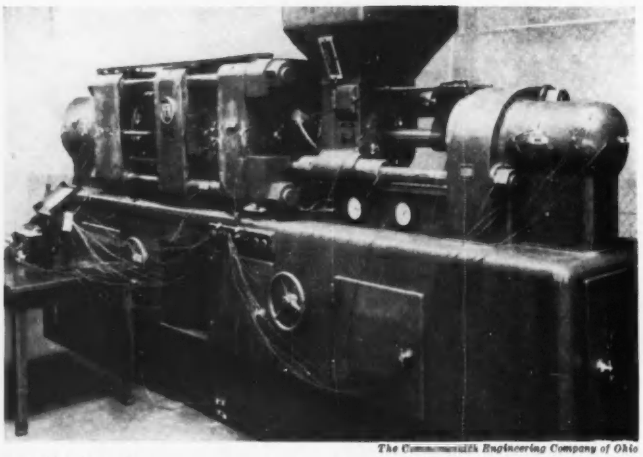
Basic research by government agencies, of course, is always in progress, and some is being done in this field. It is unlikely, however, that much of the work can be done in this manner since there are many more pressing problems of wider appeal scheduled for these groups.

A rather unusual but not unprecedented development in basic research in this field has come about with the customer doing the work. Recently the General Motors Corporation has become interested in the problem of pressure transients in pipe lines. This company has initiated a research program the first results of which have been the imposition of certain specifications on the hydraulically actuated machines that they purchase. Such developments are inevitable if the customer can afford to do research that the vendor has not done. As a consequence, however, the vendor must ultimately follow through with the same type of work in self defense.



Armour Research Foundation Fluid Mechanics Laboratory

VELOCITY TRAVERSE DEVICE. A hyperdermic tube is mounted as an impact tube to measure the velocity distribution over a diameter of a rough pipe cross-section.



The Commonwealth Engineering Company of Ohio

ELECTRIC strain gages measure stresses in parts of hydraulic injection machine.

Conclusion

On the basis of available evidence, it appears that there is a need for a great deal of research in the field of industrial hydraulics. But there remains considerable doubt as to whether it will be done soon or at all, and if it is done it is not clear who will most likely do it. Yet it has been shown that this research is possible provided reasonable amounts of money are made available, proper personnel and equipment are secured and time is allowed to do the work.

One looks forward to the day when research in this industry will be on a high plane. One hopes that it will no longer be necessary, as it was a year ago, to interrupt the delivery of a technical paper on hydraulic transmissions with an elementary explanation of the necessity for a fixed reaction in a transmission in order to secure an output torque different from the input torque. A visiting European, an expert on hydraulic transmissions, found difficulty in believing that more than three-quarters of the audience, composed of hydraulic engineers, were unfamiliar with this basic concept of mechanics.

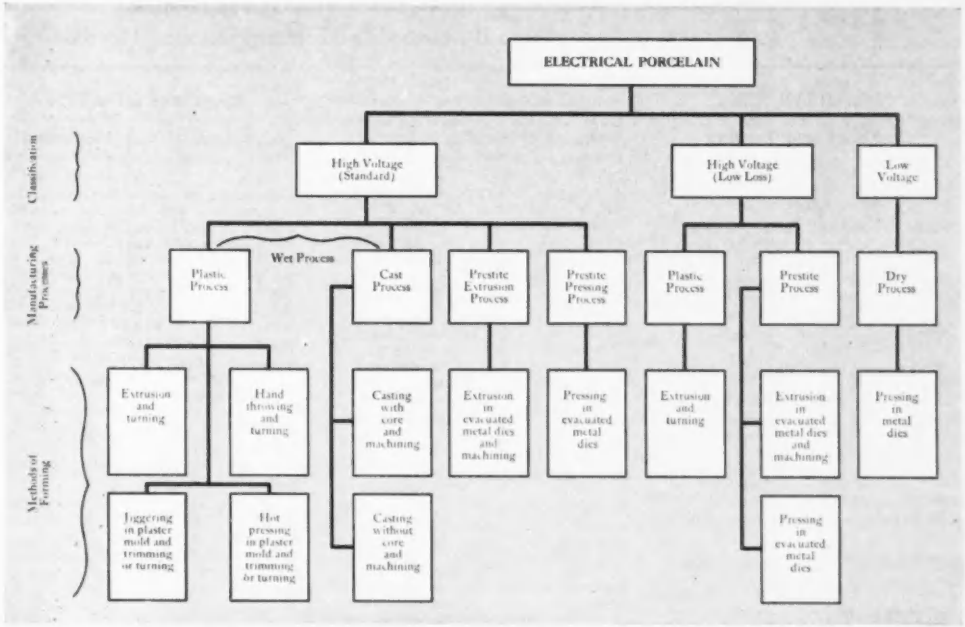


Fig. 1—Basic types of electrical porcelain, and methods of forming them into finished parts. The production process chosen governs the tolerances that can be held and often the properties of the finished part, as explained in detail in subsequent tables.

Forming Electrical Porcelain

How production methods affect design of electrical porcelain parts. Types and general properties of high and low voltage porcelain. Recommended tolerances and other design details.

P. A. PONTIUS
Materials Engineer
Westinghouse Electric Corporation

WHETHER OR NOT an electrical component can be successfully made of porcelain depends on whether the proper material is specified, and on whether the most practical forming method is used for its production. The first of these factors affects the operation of the part in service, while the second affects the design of the part as well as its quality and cost.

In general, electrical porcelain can be classed either as high voltage (standard or low loss) or as low voltage. The average properties of each of these types is shown in Table I. However, the characteristics of high voltage porcelain vary considerably, particularly with respect to mechanical strength. The characteristics of low voltage porcelain are even more variable, because the type of body and the pressing procedure directly affect the porosity of the finished product. Therefore, the values given should be taken as representing an average product, and considered as general information only. The important consideration in the choice between high and low voltage porcelain is the fact that low voltage porcelain should be considered as a mechanical spacer only and not as a dielectric spacer.

High voltage porcelain can be produced by any one of several processes, as shown in Fig. 1. The oldest, most diversified and generally used process for making high voltage porcelain is the plastic process.

The body or the raw material composition used for this process is composed of a blended mixture of ball

Table I—Properties of Standard Electrical Porcelain

Characteristics	High Voltage	Low Voltage
Dielectric Strength, Volts/Mil	200	50 to 100
Tensile Strength, psi	5000	3000
Compressive Strength, psi	48000	40000
Modulus of Rupture, psi	11000	5500
Impact (Charpy Machine) *Kg*-Cm per Sq Cm	1.75	1.25
Water Absorption	0	0.5 to 1
Specific Gravity	2.4	2.2
Thermal Conductivity—watts per sq. in. per in. per degree C	0.022	0.018

Table II—Methods of Forming Electrical Porcelain

PLASTIC PROCESS

Extrusion and Turning

Description: De-aired blanks are pushed through an extrusion cylinder having a specially shaped nozzle or die.

Shapes Obtainable: Round, rectangular, hexagonal, blanks or tubes of constant cross section.

Finishing: Turned straight, tapered, corrugated, skirted or grooved after drying. The tubes may be tapered or counterbored.

Advantages: Economical method of producing simple shapes.

Disadvantages: Can be used only for simple shapes. Fig. 2 shows the min inside dia and max outside dia to reduce high scrap losses due to the differential in shrinkage between outside and inside dia. Max outside diameter equals 18 in.

Applications: Tubes, bushings, casings, rectangular porcelain insulators for bus bars passing thru walls or floors.

Cost: Moderate labor and tool cost.

Jiggering, Trimming and Turning

Description: Treated material is worked on a table by the hands. Then this homogeneous material is dropped into a plaster-of-paris mold, which in turn is set into a revolving jiggerhead. The material is worked into the mold simulanteously by hand and by means of a profile tool or jigger shoe. Cylindrical ribs, sheds, etc. are shaped by the profile tool to approximate the final contour.

Shapes Obtainable: Bowl shaped parts and cylindrical parts with tapered round cavities at one or both ends. Bowl shapes with deep skirts.

Finishing: Finishing operations consist of trimming, cutting of reentrant curves, turning grooves, etc.

Advantages: An economical method for producing parts of moderate activity.

Disadvantages: Moderate production as compared with hot pressing.

Limitations: Max outside diameter equals 12 in.; max height, 7 inches.

Applications: Parts of large pin type insulators, outdoor apparatus insulators and blanks for indoor post type insulators

Cost: High labor cost, moderate mold cost.

Hand Throwing and Turning

Description: Cut blank of treated material is placed on a revolving plaster disk or table and manually formed to shape.

Shapes Obtainable: Hollow blanks, solid blanks, and round hollow shapes.

Finishing: The final outside and inside surfaces are turned.

Advantages: Economical method for producing round blanks that cannot be extruded.

Disadvantages: Slow production and highly skilled labor required.

Limitations: Min inside dia equals $\frac{1}{2}$ in.; max outside dia equals 8 in.; max length or height, 24 inches.

Applications: Cable pot heads, bushings with irregular inside contour, closed end bus supports. Bushings having sudden reduction of bore to small size over a short distance at one end.

Cost: High labor and inexpensive tools.

Hot Pressing, Trimming and Turning

Description: Treated material is worked and placed into plaster-of-paris mold by hand. The heavy mold with content is then placed underneath the hot-pressing tool of a suitable machine. This tool is a heated, rotating metal form shaped to imprint the convex (usually the lower) side of the desired insulator into the content of the mold. The inside of the mold is shaped to approximate the concave (usually the upper) side of the part. After the oily, hot and rotating metal tool has been pressed down and then retracted, the preliminary forming of the part is accomplished.

Shapes Obtainable: Bowl shaped parts and cylindrical parts with tapered round cavities at one or both ends. Bowl shapes with ribs and skirts, not as deep as in jiggering method can be obtained.

Finishing: After some more drying the preliminary form can be trimmed, reentrant curves cut, grooves turned, etc.

Advantages: More economical and parts may be furnished at a higher rate of production as compared with the jiggering method.

Disadvantages: Suitable for parts of high activity only (approximately 1000 and above per order, depending upon the size of the piece).

Limitations: Max outside dia of 12 in. Max height of piece of 7 in.

Applications: Suspension and pin type line insulators, outdoor apparatus insulators, small lightning arrester casings.

Cost: High tool cost; high set-up cost; moderate labor cost.

CASTING PROCESS

Casting in Plaster Molds and Machining

Description: An electrolyte is added and is mixed well with the treated materials to form the liquid slip. This slip is poured into plaster-of-Paris molds. Most of these molds are split to facilitate removal of the cast shape from the mold. After the core has been withdrawn from the inside and after the casting has been dried, the part is ready for final machining.

Shapes Obtainable: Large round and tubular shapes, conical shapes, shapes curved similar to pipe elbows or elbow extensions, etc., i.e. irregular shapes of the larger size (not having an axis of rotation) which cannot be produced economically by the four previously mentioned methods.

Finishing: Turning, cutting reentrant curves, grooving, undercutting, required.

Advantages: An economical method for producing irregular shapes especially in larger sizes.

Disadvantages: Large number of molds required, slow rate of production.

Limitations: Max outside dia of 32 in; Max height of 80 in. Max weight of 1,400 pounds.

Application: Cable entrance bushing for pole transformers. Large porcelain insulators for air breakers, weather casings.

Cost: High labor cost, high mold cost.

DRY PROCESS

Pressing in Metal Dies

Description: In addition to the operations given fully in the text the charge is weighed for obtaining close tolerances.

Shapes Obtainable: Flat and ribbed plates of any form and curves with and without holes, slots, recesses, and barriers. Intricate box-shapes with ribbed partitions and side-holes or slots.

Finishing: Usually no machining with exception of some trimming.

Advantages: An economical method of producing intricate shapes of high activity having a structure permitting moisture absorption and relatively close dimensional tolerances.

Disadvantages: The resulting finished ceramics are not impervious. They absorb moisture and are not recommended for high voltage use or in damp locations.

Limitations: Max height of ¯ in. Max

clay, China clay, pulverized quartz, pulverized feldspar and water. At the time of preliminary forming this plastic body has about the consistency of commercial putty. Any one of four methods may be used for producing the preliminary shape of the desired porcelain, namely, extrusion, hand throwing, jiggering or hot pressing. The details and advantages of each method are described in Table II. The selection of the method for preliminary forming depends mainly upon the anticipated activity and the available equipment for obtaining the desired final shape at the lowest cost.

After preliminary forming, the ware is subjected to a drying period in a chamber with suitable temperature and humidity control. The degree of drying during this operation depends upon the dimensional accuracy desired in the finished insulator, i.e. the commercial or close tolerances required.

The final shaping of the insulator to correspond to the dimensions on the drawing is done on a lathe. After final shaping, the dried insulator is ready for glazing and firing.

If a glazed surface is desired, it is

length of 12 in. Max width of 10 in. Max projected area of 120 sq. inches.

Application: Terminal blocks, supports for edgewound resistors, arc-chute liners, contactor boxes.

Cost: Moderate labor cost. High tool cost.

PRESTITE PROCESS

Pressing in Evacuated Dies

Description: This process is the same as covered fully in the text except that the charge for the cavity of the forming die must first be weighed.

Shapes Obtainable: Chiefly flat plates of rectangular, round or otherwise curved shapes with or without ribs and bosses.

Finishing: Shapes usually do not require any machining except trimming.

Advantages: An economical method for producing simple shapes of high activity requiring impervious cross section and close dimensional tolerances.

Disadvantages: Care must be exercised to produce impervious cross sections.

Limitations: Max. height of 7 in. Max length of 12 in. Max width of 10 in. Max projected area of 120 sq inches.

Applications: Electronic tubes, sockets, and bases; washers, bushings.

Cost: Moderate labor cost. High tool cost.

Extrusion in Evacuated Dies and Machining

Description: Usually several cavities and nozzles are provided for extruding in one stroke of the press.

Shapes Obtainable: Round blanks or tubes of symmetrical cross section may be obtained the same as in extrusion and turning except smaller in dia and length.

Finishing: The outside contour of the shapes may be machined straight, tapered, corrugated, grooved, etc. The tubes may be tapered inside or counterbored.

Advantages: An economical method of extruding small pieces of high activity to close dimensional tolerances.

Disadvantages: Can be used only for straight bushing, tubes, blanks.

Limitations: Max outside dia of 1.625 in. Max length of 10.0 in. Min inside dia of 0.140 inches.

Applications: Small bushings, tubings for electronic and radio apparatus.

Cost: Moderate labor cost, high tool cost.

obtained by dipping or spraying the part with a mixture of the glazing materials suspended in a relatively high percentage of water. The moisture added during the glazing operation makes subsequent drying of the ware necessary before firing.

Firing in the kiln is completed at approximately 2200 F. During firing the physical, electrical and mechanical properties as well as the physical and chemical structure, gravity and hardness of the shaped ware are basically changed; firing also results in permanent volume shrinkage of approximately 25 percent.

The plastic body for high-voltage, low-loss porcelain contains a large percentage of zircon. Ball clay, alkaline earth fluxes and other additions together with this zircon constitute the raw material composition. Some moisture content at the time of preliminary forming will give the body a consistency similar to putty.

So far only the extrusion and turning method of forming has been developed for this zircon type of plastic body. All other conditions during the manufacturing process are the same as for the plastic body for the high voltage-standard porcelain. The firing conditions are also the same.

The cast process is used for making the high voltage-standard porcelain. It is applicable to a wider range of sizes than the plastic process, but is usually limited to irregular shapes (shapes not having an axis of rotation), large pieces, weather casings and tapered tubes.

The raw material composition of the cast body used for this process has approximately the same ingredients as the plastic body for the high-voltage standard porcelain. Its moisture content is also approximately the same. By adding a small quantity of chemicals (electrolytes), the resulting mixture becomes a free-flowing liquid and it is called "slip".

This slip is poured into a plaster-of-Paris mold that is shaped to approximate the contour of the finished piece. Allowances are made for the anticipated shrinkage during drying and firing, to insure a sound casting and to permit the cast shape to be removed from the mold.

The porous plaster of the mold absorbs some of the water from the poured slip. This gradual infiltration of water from the slip into the plaster mold deposits the solids of the slip onto the walls thus forming the shell or outside contour of the desired piece. Provided the mold is continually refilled with slip, this shell grows in wall thickness as more water is absorbed into the mold and more solids are deposited on the inside, until the desired thickness is built up or the space in the mold is entirely filled.

A porcelain piece of which the inside dimensions or contours are not important is formed by drain casting, i.e., without a core. When using this method, the mold is maintained full of slip until the desired wall thickness of the piece has been formed as a rather stiff shell inside the plaster mold; then the excess slip is drained from the shell or casting. In case the inside dimensions of the porcelain are important, the piece must be cast with a core.

The dry process is approximately the next to the oldest process practiced by the industry. It is used for relatively small, irregular and intricate shapes of high activity for low voltage porcelain and for electrical refractories.

The dry process body for low voltage porcelain contains approximately the same raw materials as the plastic body except that its moisture content at the time of forming is slightly less. This blended mixture is broken up into small particles about the size and the consistency of coarse and wet sawdust, which permits forming under pressure. Such material is placed into a metal mold or die and pressed to shape. This die usually has one cavity, but in cases of high activity, a multicavity die may be more economical. The molded piece is dried, trimmed, glazed, if required, and fired the same as in the plastic process.

The Prestite process is a late Westinghouse process used for producing small pieces and simple shapes of high activity and of relatively close dimensional accuracy. This close dimensional accuracy is obtained by reducing the moisture content of the body,

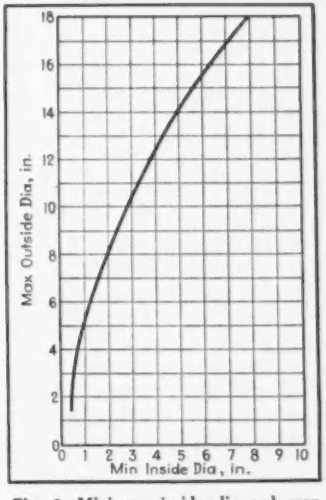


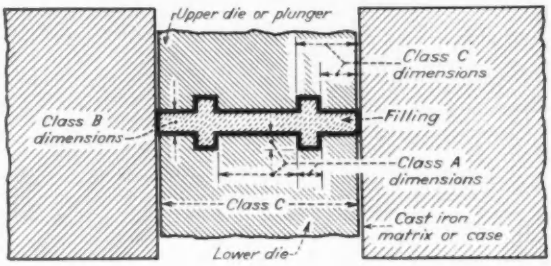
Fig. 2—Minimum inside dia and max permissible outside or shoulder dia of finished tubes made by extrusion. A larger outside dia or smaller inside dia are permissible providing that the wall has sufficient strength to support the part during firing. Otherwise, breakage will result.

Table III—Tolerance Recommendations for Electrical Porcelain Parts

CLASS A DIMENSIONS are determined by fixed die parts.

CLASS B DIMENSIONS are determined by the motion of the upper die part or plunger into the case or matrix. The variations of this class of dimensions depend upon the variations in pressure used and upon the variation of the quantity of filling in the cavity of the die.

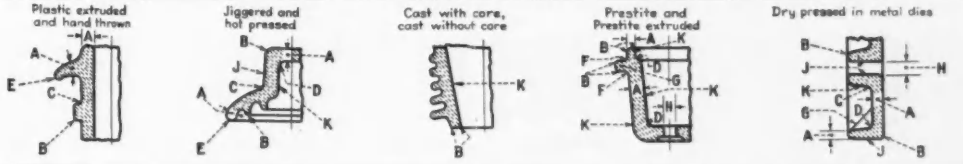
CLASS C DIMENSIONS are determined by the matrix or case. The variation of this class of dimensions depend upon the wear of the matrix or case and upon the wear of the die or plunger.



Type of Material and Production Process	Tolerance Classification	Dimension			Recommended Tolerance, plus or minus
		Type	Class	Size, in.	
High voltage standard porcelain made by the plastic process or cast, or plastic high-voltage, low-loss porcelain	Commercial	Between glazed and unglazed surfaces	.....	Up to 1.0 Over 1.0	0.031 in. 3.0 percent
	Close	Between glazed and unglazed surfaces	.....	Up to 1.0 Over 1.0	0.020 in. 2.0 percent
High voltage standard and high-voltage, low-loss porcelain made by the Prestite process	Commercial (Non-Critical)	Between glazed and unglazed surfaces	*A* and *C* *B*	Up to 1.0 Over 1.0 to 12.0 5/32 to 1/4 Over 1/4 to 1/2 Over 1/2 to 1.0 Over 1.0	0.020 in. 2.0 percent 0.030 in. 0.032 in. 0.035 in. (0.015)+2.0 percent of dimension
	Close (specify only if commercial tolerances are not feasible)	Between glazed and unglazed or glazed surfaces	*A* *B* *C*	Up to 5/8 Over 5/8 5/32 to 1/4 Over 1/4 to 1/2 Over 1/2 to 5/8 Over 5/8 Up to 3/4 Over 3/4 to 12	0.012 in. 2.0 percent 0.022 in. 0.024 in. 0.027 in. (0.015)+2.0 percent of dimension 0.016 in. 2.0 percent
		Between unglazed surfaces	*A* *B* *C*	Up to 1/4 Over 1/4 to 1.0 Over 1.0 5/32 to 1/4 Over 1/4 to 1/2 Over 1/2 Up to 1/4 Over 1/4 to 1.0 Over 1.0 to 12.0	0.005 0.010 1.0 percent 0.015 0.020 (0.015)+1.0 percent of dimension 0.009 0.014 (0.004)+1.0 percent of dimension
Low voltage porcelain and electrical refractories made by the dry press process	Commercial (Non-Critical)	Between glazed and unglazed surfaces	*A* and *C* *B*	Up to 1.0 Over 1.0 to 12.0 3/16 to 1/4 Over 1/4 to 1/2 Over 1/2 to 1.0 Over 1.0	0.020 2 percent 0.035 or 0.030* 0.040 or 0.032* 0.045 or 0.035* (0.025)+2.0 percent of dimension (0.015)+2.0 percent of dimension*
	Close (Specify only if commercial tolerances are not feasible)	Between glazed and unglazed, or between glazed surfaces	*A* *B* *C*	Up to 3/4 Over 3/4 3/16 to 1/4 Over 1/4 to 1/2 Over 1/2 to 3/4 Over 3/4 Up to 7/8 Over 7/8 to 12	0.015 2.0 percent 0.030 or 0.025* 0.035 or 0.027* 0.040 or 0.030* (0.025)+2.0 percent of dimension (0.015)+2.0 percent of dimension* 0.018 2.0 percent
		Between unglazed surfaces	*A* *B* *C*	Up to 1/4 Over 1/4 to 1.0 Over 1.0 3/16 to 1/4 Over 1/4 to 1/2 Over 1/2 Up to 1/4 Over 1/4 to 1.0 Over 1.0 to 12	0.008 0.015 1 1/2 percent 0.023 or 0.018* 0.033 or 0.023* (0.025)+1½ percent of dimension (0.015)+1½ percent of dimension* 0.012 0.019 (0.004)+1½ percent of dimension

* Recommended only if charge is weighed.

Table IV—Design Recommendations for Electrical Porcelain Parts


Plastic extruded and hand thrown
Jiggered and hot pressed
Cast with core, cast without core
Prestite and Prestite extruded
Dry pressed in metal dies

Forming Method	Height of Boss, Shoulder or Depth of Depression, in.	Fillet Radius *C*	Fillet Radius *D*	Draft	Remarks
Plastic: hand thrown and extruded	Up to 3/32 3/32 to 3/4 Above 3/4	Equal to height 3/32 in. Preferably 1/8 of height 3/32 in. min.	Equal to depth 3/32 in. Preferably 1/8 of depth 3/32 in. min.		Bead *E* at edge functions as a "rain drip" and assists in holding shape of water shed during firing.
Jiggered, hot pressed and cast	Up to 1/4 1/4 to 2.0 Above 2.0	Equal to height 1/4 in. Preferably 1/8 of height 1/4 in. min.	Equal to depth 1/4 in. Preferably 1/8 of depth 1/4 in. min.	1/32 in. per side for mold and for retracting tool with jiggered and hot pressed parts. Two deg for cores of cast parts	Holes less than 3/8 in. dia preferably should be unglazed unless they need not be held to close tolerances, as with ventilation or drainage hole. This also applies to parts made by other methods.
Prestite and dry pressed parts	Up to 3/32 3/32 to 3/4 Above 3/4 Up to 1/4 1/4 to 2.0 Above 2.0	Equal to height 3/32 in. Preferably 1/8 of height 3/32 in. min.	Equal to depth 1/4 in. Preferably 1/8 of depth 1/4 in. min.	Plain outside surfaces and through holes can be made without draft. Bosses counterbores, or depressions should have wall drafts not less than 1/32 in. per side.	Protruding ribs or flanges *F* joining on outside surfaces should have a minimum radius of 1/16 in. Thin walls should be braced to prevent distortion during firing.

thus reducing the shrinkage, and also by the use of metal dies for forming, in the case of high voltage porcelain. The moist body is granulated into small particles. The particles or powdered body is loosely filled into metal dies to facilitate evacuation before the high pressure for extrusion is applied. The extruded blanks may be cut to length, trimmed, and glazed if required, then fired the same as in the case of the plastic process.

Part Design

To obtain consistent high quality during production, the limitations and advantages of each of the various forming methods should be thoroughly understood. In addition, good design practice, gained through experience with each of these methods, should be followed. While it is impractical to discuss all of the recommended procedures in detail, they can be summarized so that the general problems are brought out. Adherence to the following recommendations will decrease the number of rejected parts:

1. Avoid abrupt changes in section thickness. Such changes may cause non-uniform drying and result in fine cracks.

2. Specify close tolerances only when necessary. In few instances can the recommended tolerances listed in Table III be exceeded.

3. Specify overall dimensions of ground surfaces both before and after grindings, so that adequate allowance can be made for shrinkage.

4. If possible, provide bosses on flat surfaces so that the entire surface need not be ground. Around cored holes the bosses should be at least ¼ in. larger than the hole diameter.

5. Round off sharp edges on the part to decrease die maintenance cost and to improve part appearance. Sharp edges chip easier when the part is handled, and glazes may pull away from edges sharper than 1/16 in. on bosses, projections, and outside radii during firing.

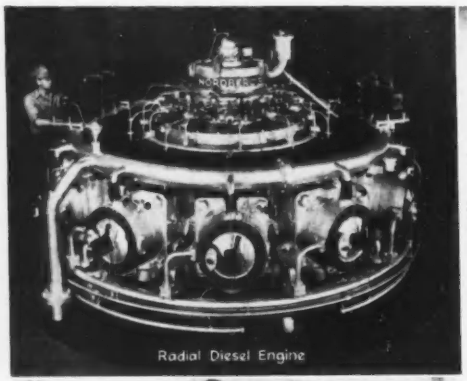
6. Base the fillet radii of depressions on bosses, shoulders, webs and ribs on the height of these sections, as shown in Table 4.

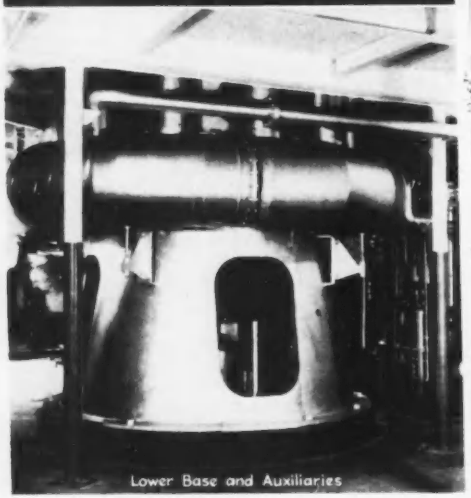
7. Base the fillet radii of depressions on counterbores on the depth of these sections, as shown in Table IV.

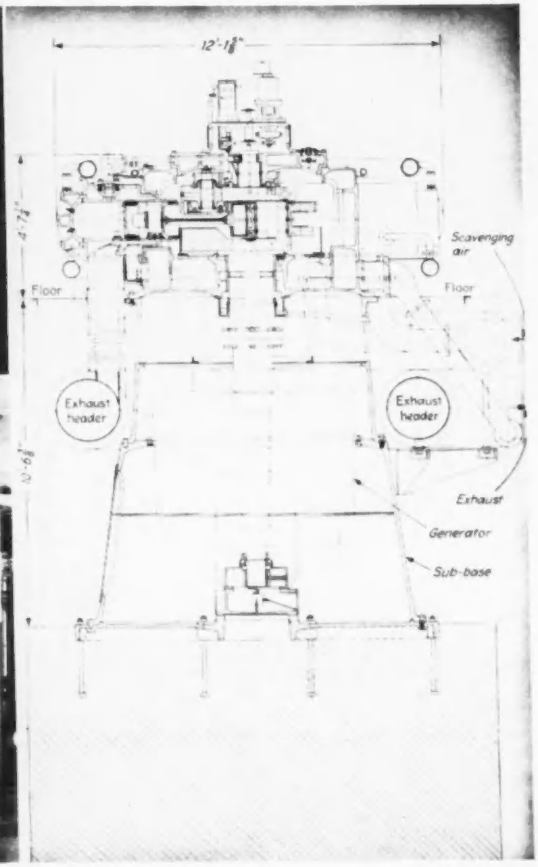
8. If the part is to be ground, establish a base line from which the axial dimensions can be laid out, and provide a total grinding allowance that includes an allowance for shrinkage and an allowance for eccentricity and flatness. In general, the shrinkage allowance should be approximately the product of the percent shrinkage of the material (percentage value from commercial tolerance specifications) multiplied by the sum of the min axial dimensions between the base line and the ground surface, and one-half the total permissible tolerance pertaining to this dimension. The allowance for flatness is usually taken as 1/32 in. for surfaces less than 5 in. in outside dia, and 1/16 in. for surfaces more than 5 in. in outside diameter.

9. Print style numbers and other identifications in ceramic ink on the unglazed surface of parts to be produced by the cast process, the plastic process, and the Prestite extrusion process. Specify raised lettering—not depressed—only on dry pressed parts or Prestite parts made by other methods than extrusion; if possible, it is preferable to have these block letters on a depressed surface.

10. Select the firing surface so that the piece is not top heavy, and thus does not tip over in the kiln. Long, flat pieces should be rested on one side to reduce warpage. In no case can the surface selected for support be glazed.



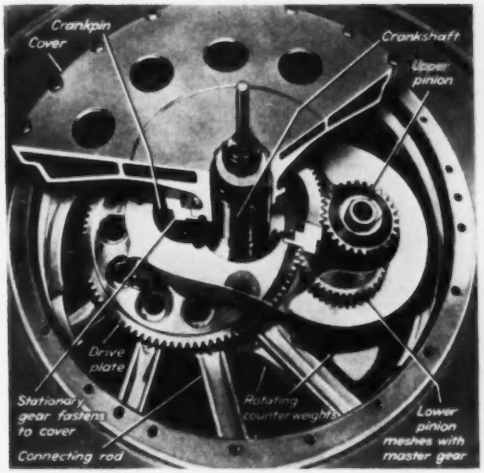




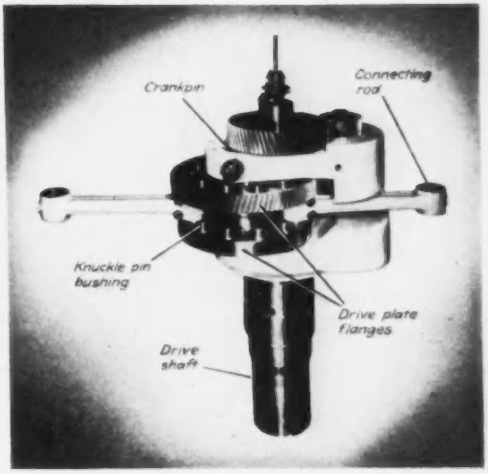
IN THIS APPLICATION, the 11-cylinder radial diesel engine drives an electrical generator. The vertically-mounted, directly-connected engine and generator installation rises through two levels of the plant. A concrete block on the lower floor supports the steel sub-base of the engine. This sub-base also carries the stator of the generator.

Stationary Radial Engine is Convertible To Natural Gas, Diesel Fuel or Both

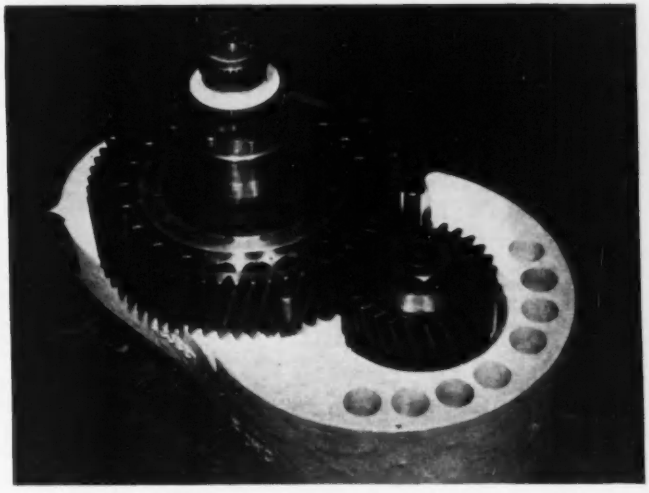
Compactness was the reason that a radial cylinder arrangement was chosen for this stationary engine. The Nordberg Manufacturing Company of Milwaukee developed the engine for applications in the generation of electrical power. A complete installation of engine and generator requires only 18 ft headroom and 12 x 12 ft of floor space. With slight modifications, the engine will operate either as a spark-ignited natural gas engine, as an oil burning diesel or as a combination oil-natural gas diesel. To minimize vibration, Nordberg engineers eliminated need for master rod used in conventional radials. A second departure was addition of counterweights. Engine is a two-cycle type with 11 cylinders of 14 in. bore and 16 in. stroke. It develops 1800 hp at 400 rpm, which is normal operating speed. Engine weighs 39 lb for each hp produced.



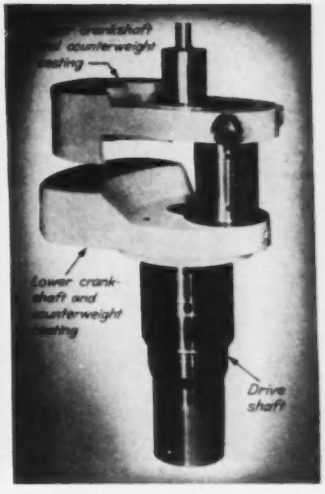
ABSENCE of the master connecting rod that is used in conventional radial engines results in a symmetrical design. Thus, vibration is kept to a minimum. In the new engine, all connecting rods are identical and transmit power tangentially to the drive plate. As the cylinders fire in their numerical order, the drive plate does not rotate but moves along a circular path around the crankshaft axis. The drive plate in turn transmits motion to the crankpin passing through its center. The crankshaft drives the load.



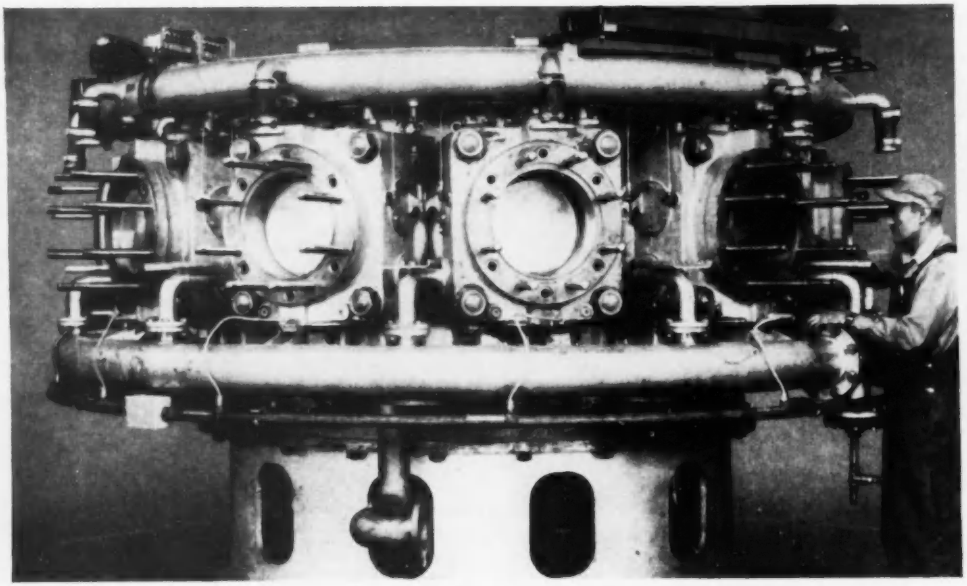
CONNECTING RODS are rigidly held in the vertical plane. The rods actually carry the pistons, which thus reciprocate along the true axes of the cylinders. This design eliminates the uneven wear caused by pistons riding on the cylinder walls. To accomplish this, each connecting rod knuckle pin is mounted between the two flanges of the drive plate. The diameter of the knuckle pin and wide spacing between bearing surfaces are sufficient to rigidly support the connecting rod in its horizontal travel.



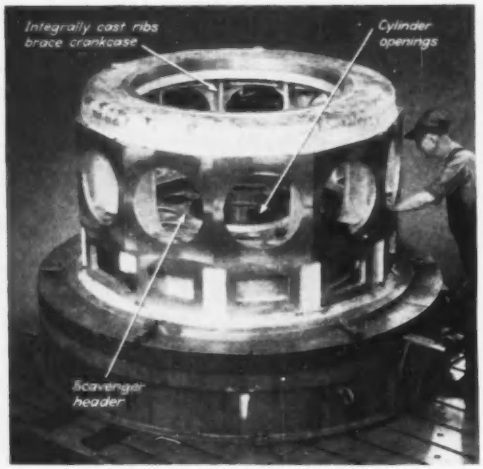
GEAR TRAIN PERFORMS ONE FUNCTION of the master rod in conventional radials. These gears control the gyratory movement of the drive plate in its relation to individual pistons and their firing order. If the plate could rotate freely, the correct positioning of the various moving elements could not be maintained. The gears transmit no power.



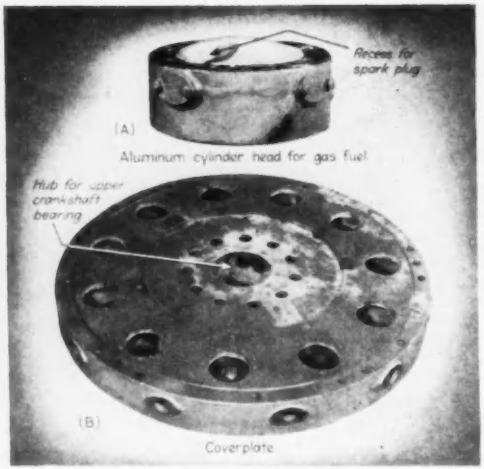
TWO-PIECE crankshaft is cast iron. Two-piece design makes possible use of one-piece drive plate. If plate were segmented, it would be hard to make. (*continued on next page*)



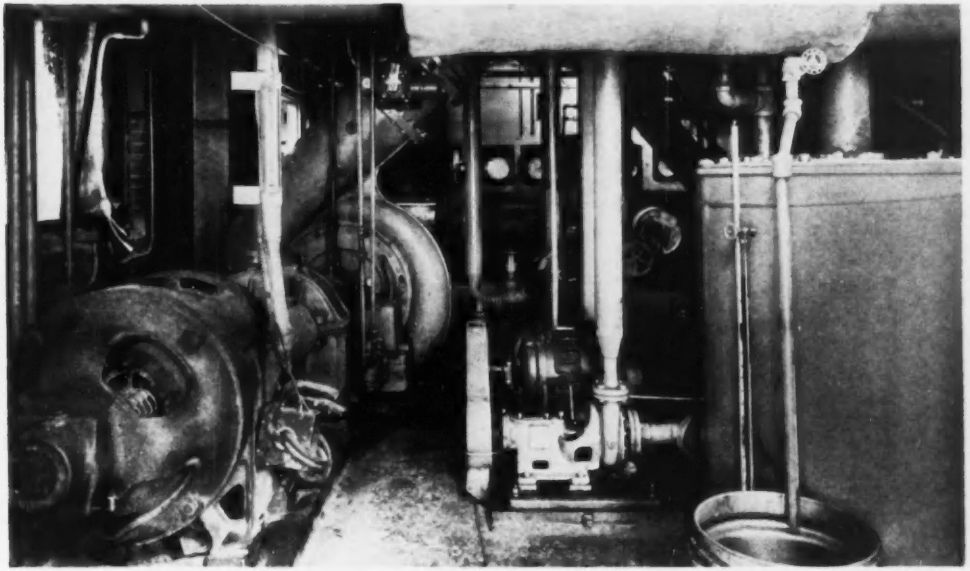
CYLINDERS are one-piece castings of a close grain alloy. Liners are not used. In cylinders equipped with liners, there is possibility of leakage of gas and water at joints and seams. Because of the many port openings necessary in a two-cycle engine, the leakage problem would be considerable were liners employed. Scavenger and exhaust openings in the cylinder are located so as to minimize space required for headers or ducts. Scavenging air passes through an internal header in the crankcase. Flexible tubing connects each cylinder exhaust port with the main exhaust header, which is located immediately below the upper floor level. All engine parts are accessible for servicing.



CRANKCASE has scavenger header cast integrally with it to conserve space and to simplify inlet port connections to the cylinders. Four 2¼ in. studs hold each cylinder in place. Ample metal is cast into the crankcase wall and rib sections to receive the large studs and to insure maximum rigidity in supporting the cylinders.

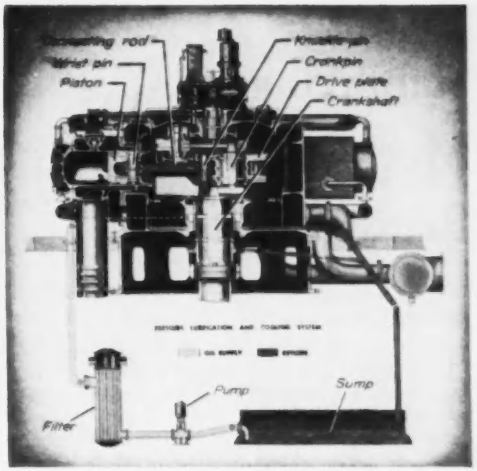


CYLINDER HEAD design depends on fuel to be used. Diesel head is cast iron and has single opening for oil injection in place of two spark plug holes in aluminum head. Engine cover plate holds the stationary gear of the crankshaft gear train. It is this stationary gear that determines the path that the drive plate must travel.

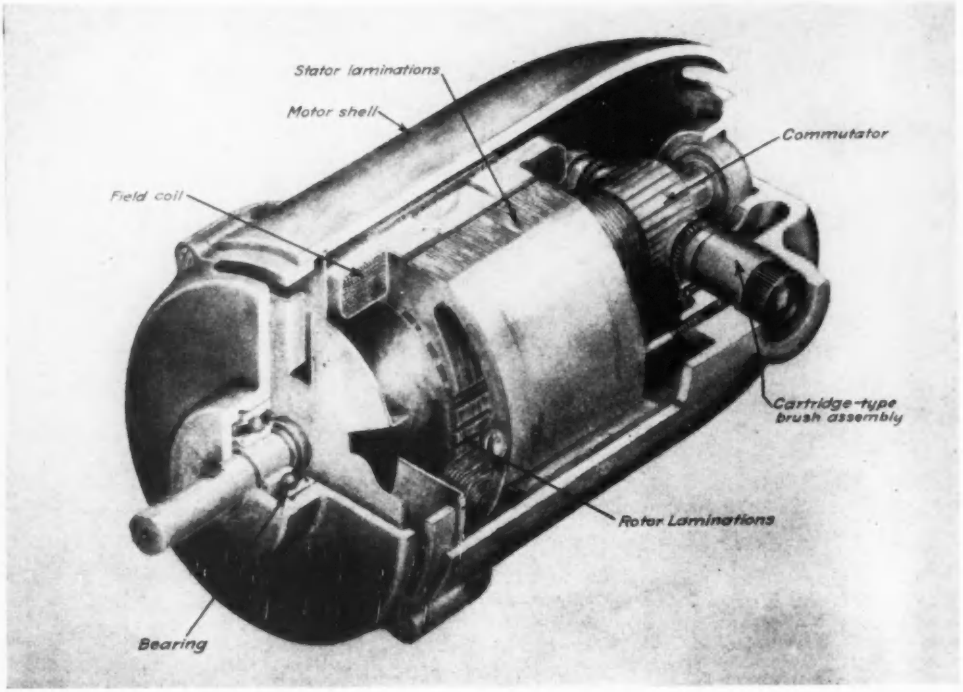


SCAVENGING AIR is supplied by a centrifugal blower situated on the lower level. The electrical generator supplies power to the blower motor. Thus, blower operation is automatic. It delivers air only while radial engine is running and in direct proportion to engine speed. The blower consumes 100 kw of the total 1250 kw delivered by the generator. In addition to auxiliaries on lower level, certain components are mounted atop the engine. The governor, grease pump for centralized lubrication and fuel pump are located there. Cam fixed to upper crankshaft actuates the fuel pumps. Cam can be rotated on the shaft thus changing the time of fuel injection.

ALUMINUM ALLOY PISTONS are machined as two separate units. After machining, the cooling ring is shrunk fitted to the piston and welded in place. This construction provides annular passages between this ring and the piston proper for the flow of cooling oil. In addition to the oil cooling system, water is circulated through cylinder jackets.



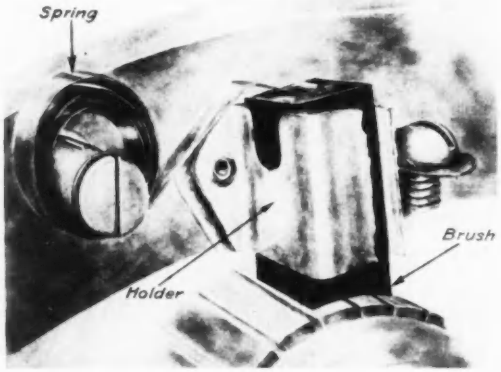
FILTERED OIL is pumped through a passage in the lower crankshaft to the crankpin. A series of drilled holes in the crankpin mate with grooves in the drive plate. Oil from these grooves is forced through an opening in the knuckle pin and a hole in the connecting rod to the wrist pin. Then, oil passes through piston to the cooling ring.



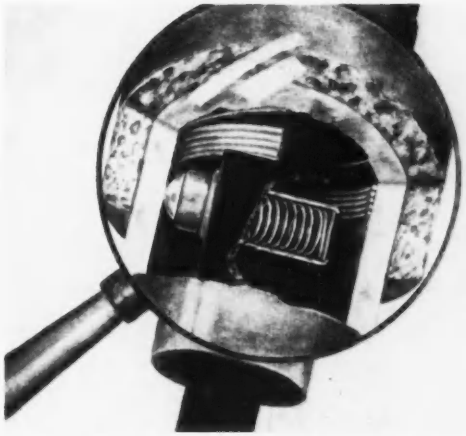
SERIES-WOUND ELECTRIC MOTORS require the use of commutators and brush assemblies. In fractional hp motors for ac-dc operation, the cartridge-type brush assembly shown above has been universally adopted. It is small and easily installed. Further advantages are simple design, low cost, speed of replacement and ruggedness.

Stabilizing Mechanism Reduces Brush Chatter

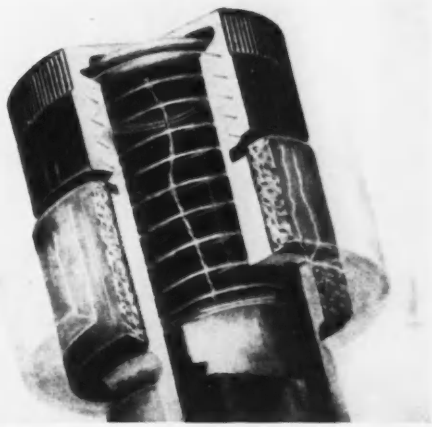
Excessive vibration or chatter is a prime cause of brush wear, noise and poor commutation in electric motors. Until recently, the cartridge type brush holder assembly was particularly susceptible to chatter. Now, C. A. Thomas of the General Electric Company in Fort Wayne, Ind., reports the development of a new cartridge assembly. The cartridge contains a stabilizing device which prevents the brush from vibrating between the sides of the brush holder. This has been done without requiring a tight fit of the holder about the brush. Thus, up and down movement of the brush due to irregularities and the general eccentricity of the commutator is not restricted.



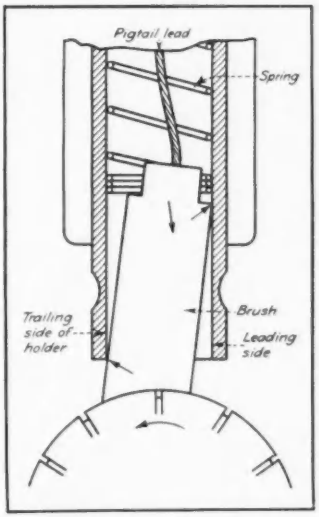
BOX-TYPE BRUSH assembly takes up more space than cartride type. However, up to now, its performance was better. Hence, the box-type assembly is widely used on larger motors where space is not a factor. In this design two forces act on the brush to keep it riding flush against the right hand side of the brush holder. One of these forces is the friction between brush and commutator. The second is the horizontal component of the spring force acting against the angled brush top.



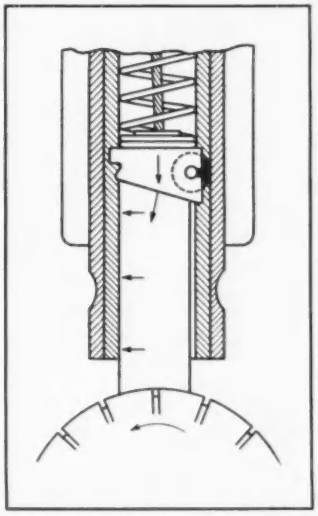
BRUSH STABILIZING DEVICE is now used in G. E. cartridge type assemblies. This new mechanism provides a means of exerting a stabilizing force against the top of the brush. It holds the brush flat against the left hand or trailing side of the brush holder. But the brush is free to move up and down without tendency to stick.



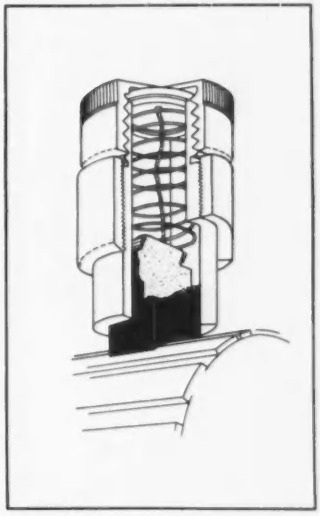
PREVIOUS ATTEMPT to reduce brush wear and chatter incorporated a spring and plunger in the body of the brush. But with this design it was difficult to prevent sticking of the brush. One advantage of the new brush stabilizing device is that brushes operate satisfactorily under only 4 psi while 6 psi was needed before.



BRUSHES in cartridge-type assemblies would not remain flush against the trailing side of the holder. Whenever an uneven or raised spot on the commutator passed under the brush, it would cause the brush to pivot about the lower edge of the brush holder as shown above. After the raised spot had passed, the brush moved back against the trailing side. This action was repeated rapidly, resulting in chatter.



CARBON WEDGE is basic part of the new mechanism. This transmits the vertical spring load and a horizontal reaction force to the inclined top of the brush. The two forces combine to hold the brush in place. A roller mounted in the wedge is in contact with the brush holder wall and provides the reaction force. The disadvantage of a sticking brush is that it does not move up easily over commutator high spots which can abrade it.

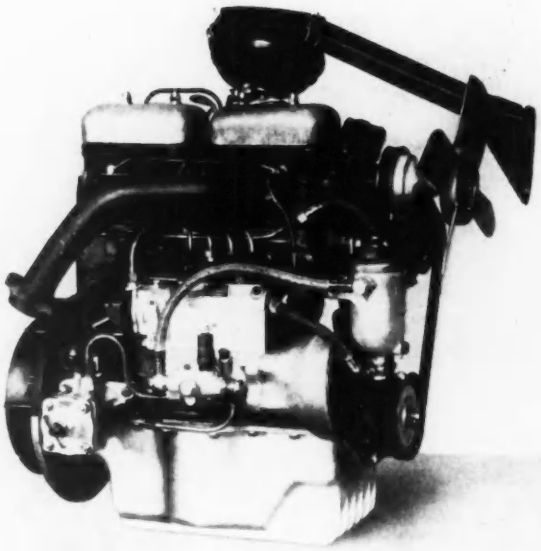


ANOTHER EARLIER SCHEME to improve the performance of the cartridge type assembly used an inclined extension on top of the brush. The coil spring then held the brush firmly in place. The objection to this design was that it reduced the usable length of the brush. The dimensions of the new assembly are the same as those of the old cartridge type holder. Thus, new type can be substituted without changing the motor design.

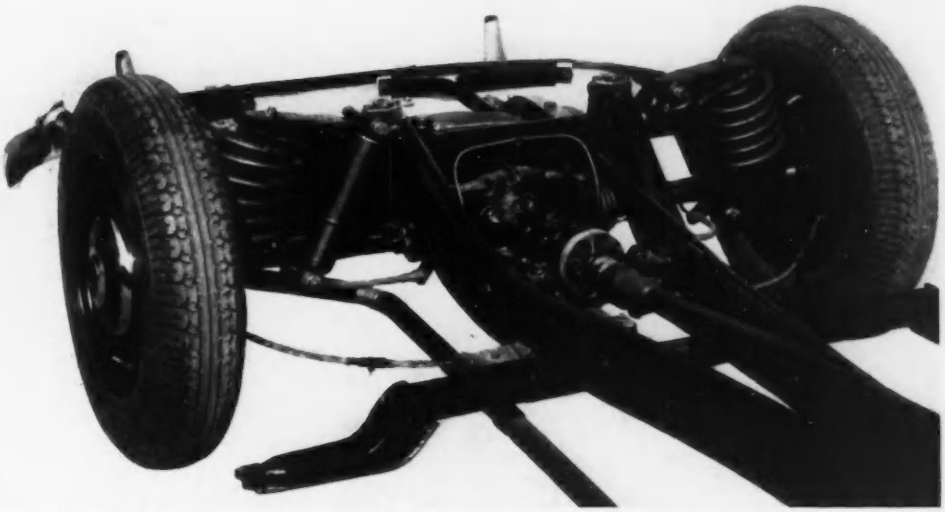
CONVERTIBLE seats two passengers. The Mercedes transmission provides 4 forward speeds with a top speed of about 75 mph. The tires used are 6.40-15, low pressure. X-shaped frame of oval pipe sections is retained in the new cars. The muffler is a short triangular box in place of the tubular construction used on American cars.

German Automobile Has Diesel Engine

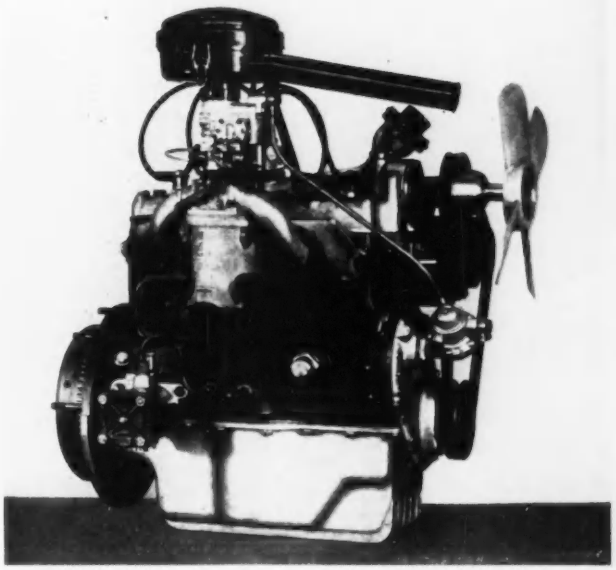
The new line of Mercedes-Benz automobiles offers a choice of either gasoline or diesel engines. The diesel is actually a redesign of the gasoline engine. For production economy, Mercedes used as many parts of the gas engine as could be adapted to diesel operation. A new gasoline engine has also been introduced. Mercedes is producing two series of cars—both on 112 in. wheelbase. The difference between the series is in body size.



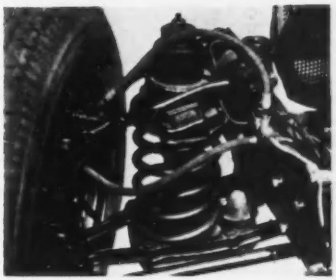
DIESEL ENGINE delivers 38 hp at 3200 rpm. The basic construction of this engine is similar to the Mercedes 38 hp gasoline engine also in production. Many parts are interchangeable between the two. The 4 cylinder diesel engine has a compression ratio of 19:1. A gray iron casting is used for the cylinder head. To accommodate the higher power drain during starting, cars equipped with diesel engines have a 12 volt electrical system.



FOUR COIL SPRINGS replace the leaf springs formerly used to carry the rear end loads. There is a pair of coils on each side, with one operating within the other. The direct-acting shock absorbers are mounted at an agle to provide a greater damping stroke. The four-wheel brakes are hydraulically operated.

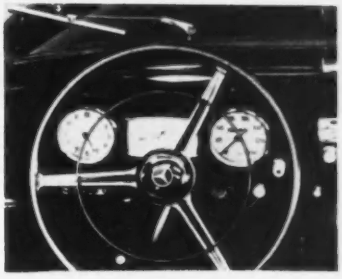


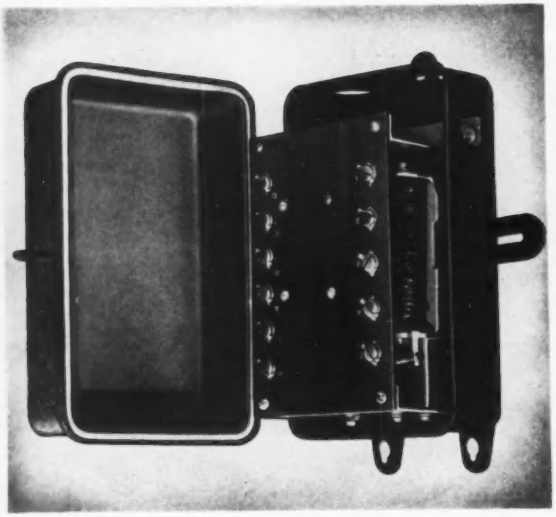
TWO GASOLINE ENGINES are available. One delivering 38 hp at 3200 rpm and the second 52 hp at 4000 rpm. The larger is shown above. Compression ratio of both is 6.5:1. The 38 hp engine has an "ascending" type carburetor which produces a proportionately richer mixture as car speed increases. In the 52 hp engine, a "descending" type carburetor is used. Thus, the manufacturer claims that at cruising speeds the gas consumption of both engines is the same.



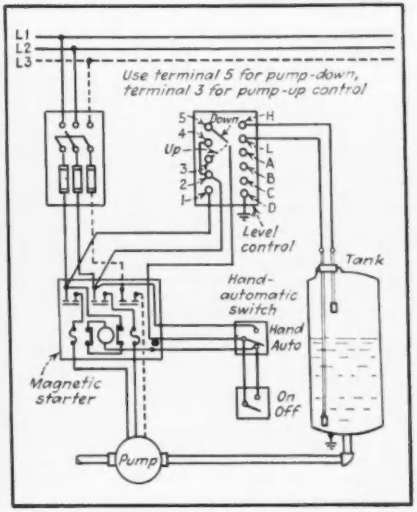
INDEPENDENT front wheel suspension uses coil springs. Airplane-type shock absorbers are mounted coaxially within springs.

HORN RING connects with rotary switch for direction signals. Turning ring in either direction actuates switch.





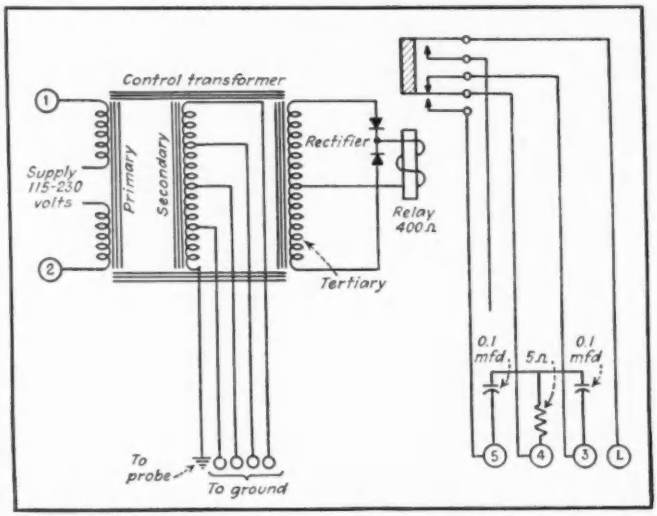
CONTROL BOX contains a three-legged transformer, a sensitive telephone-type d-c relay and a pair of germanium crystal rectifiers. The secondary winding of the transformer is tapped at four points. Thus any one of four voltages can be placed between probe and ground. The voltage selected depends upon the specific resistivity of the liquid under control. Total power consumption is ½ watt.



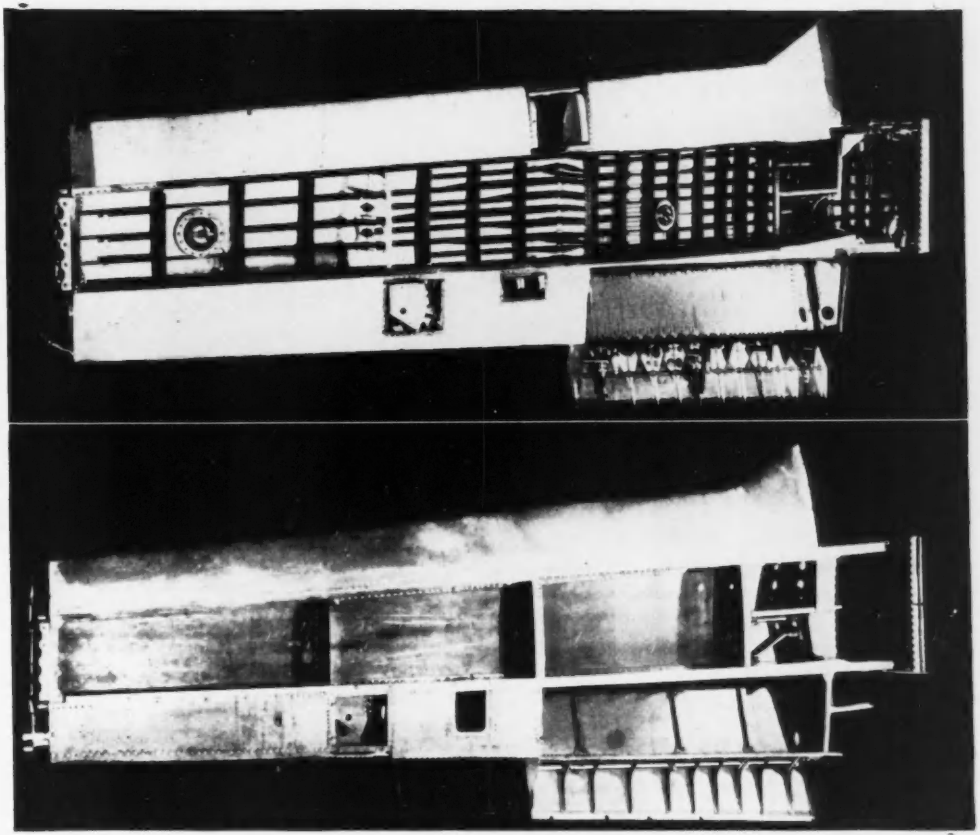
IN THIS APPLICATION, positions of probe rods in the storage tank determine duration of pump operation. When water touches upper probe, relay operates and pump stops. Through auxiliary contacts, lower probe provides relay holding current until water drop below it.

Transformer Used As Amplifier

The Photoswitch Liquid Level Control is a device for operating solenoid valves, magnetic starters, etc. when tank-contained liquids reach predetermined levels. Manufactured by Photoswitch, Inc. of Cambridge, Mass., the device uses stationary electrical probes in place of floats for liquid contact. Feature of the control is the amplification of minute currents without the use of vacuum tubes. A three-legged transformer converts the current in the probe circuits into an impulse strong enough to operate a switching relay.



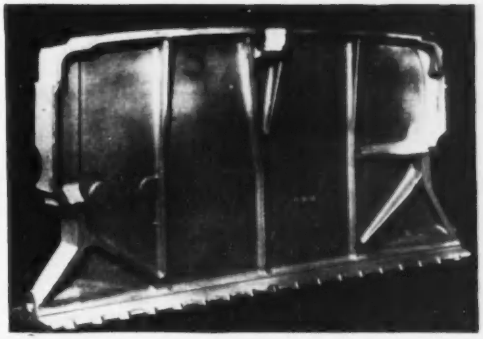
PRIMARY LEG of the transformer is excited by 115 or 230 volt a.c. supply. The resulting flux takes the path of least reluctance—through the middle leg—and induces a voltage in the tapped secondary winding. This voltage is applied to the probe. Under these conditions, practically no flux flows through the tertiary coil. But when liquid bridges the gap between probe and ground, current flows in the secondary coil, generating an mmf which opposes the original mmf. This will cause the primary flux to shift to the tertiary coil. The resulting voltage is rectified by the germanium crystals. The rectified voltage actuates the load relay.



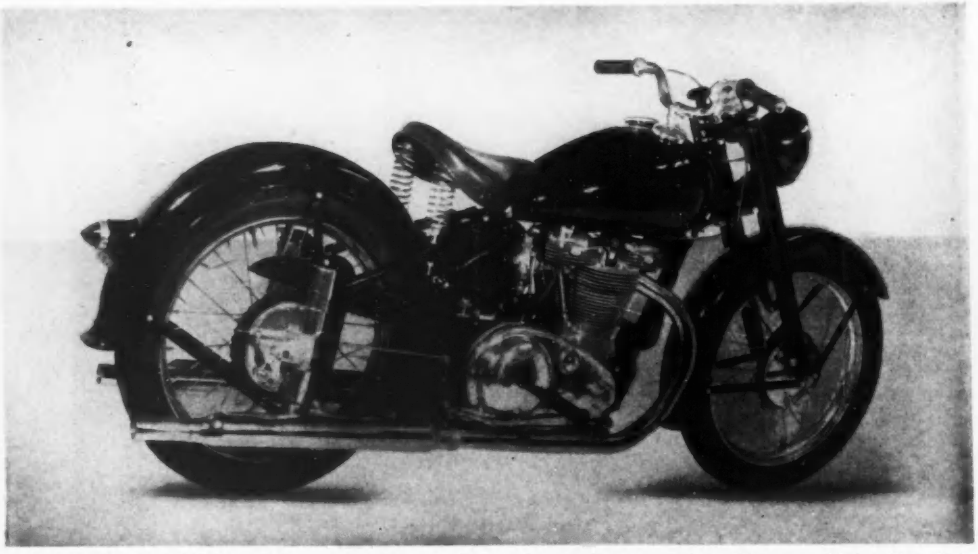
ORIGINAL ALUMINUM ALLOY WING had 1,640 separate pieces and used 42,700 fastenings. In the redesigned wing these were reduced to 508 pieces and 16,000 fastenings. The magnesium wing requires less time and labor to produce. Additional economies are realized from reduced tooling, fewer drawings, and simplified inventories. The maximum thickness of the magnesium skin is .375 in. compared with .051 in. for the original.

Magnesium Alloys Simplify Jet Wing

The designers' aim in substituting magnesium for aluminum in the wing for the F-80 jet airplane was not to reduce its weight. The objects were added strength and faster, more economical production. Magnesium's low specific gravity permits the use of a thick skin, thereby eliminating the many stringers and stiffeners needed to brace the original thin aluminum skin. In several places, intricate aluminum stampings and built-up parts were replaced by magnesium castings. East Coast Aeronautics, Inc., of New York City made the new wing.



MAIN BULKHEAD of magnesium wing is a one-piece magnesium casting. In the aluminum wing, this structure was fabricated from 25 parts and 653 fastenings.

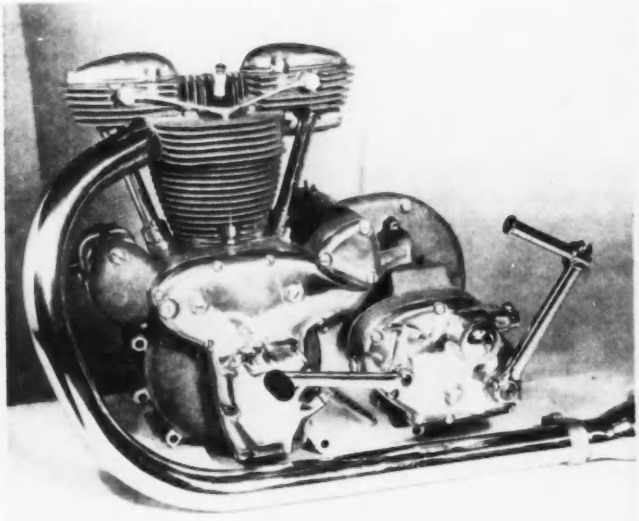


EACH TUBULAR SECTION of the front fork is actually a big direct-acting hydraulic shock absorber. These airplane type units are between handlebar and wheel. The cushioning effect of the hydraulic fluid isolates wheel vibrations from the rider. Wheelbase of the new motorcycle is about 5 in. less than before. The Indian is available in three sizes—one and two cylinder sport models and a heavy duty version. The two cylinder "Scout" is shown above. About 70 percent of the parts used in the assembly of this machine are used also in the lighter, single cylinder "Arrow." The interchangeability is an important cost consideration. The design changes reduced weight of each Indian model by more than 200 pounds. The single cylinder engine develops 11 horsepower.

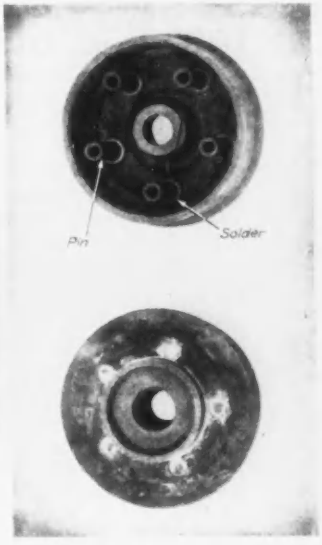
Induction Brazing Cuts Cost of Motorcycle

Lightweight, flashy performance and improved appearance were the goals of the Indian Motocycle Company in engineering the models introduced this year. Die castings and induction brazing were major features of the redesign. Production was speeded up to such an extent that part cost was appreciably lowered. The Indian plant is in Cambridge, Massachusetts.

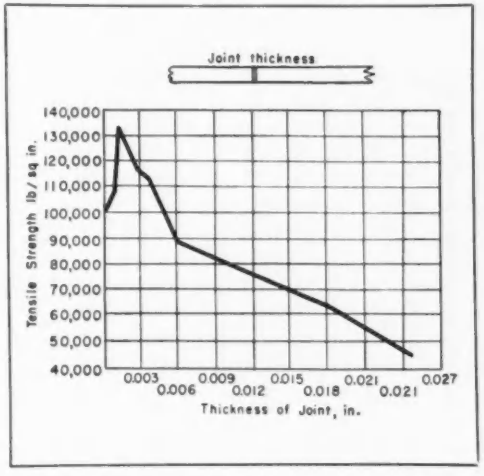
THESE STRUCTURAL PARTS are now assembled by induction brazing. Silver solder is used for all tubular joints and brass for flat joints. As an example of savings, the frame formerly was assembled by torch brazing which required 250 hr per 100 frames. By slight redesign for induction brazing, the time was reduced to 40 hrs per 100 frames. In addition, joints are stronger and more uniform. Hand sanding has been replaced by a grit blast treatment before painting. Tubing is AISI 4130 chrome-molybdenum steel.



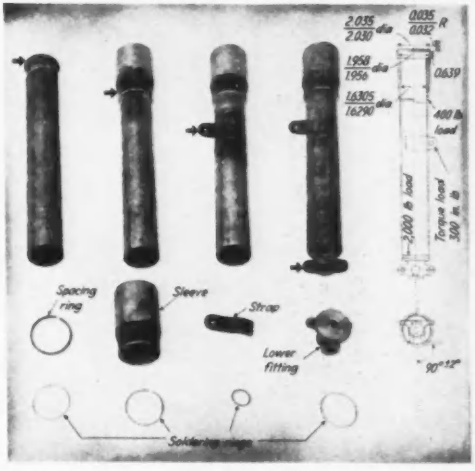
ENGINE COMPRESSION RATIO is 7 to 1. Three basic considerations governed engine redesign—resistance to corrosion, appearance and cost. Accordingly, aluminum die castings were specified for the cylinders, heads and all covers instead of the sand cast parts previously used. Iron liners are centrifugally-cast in place within the cylinders. The valve seats are steel rings that are also shrunk in after the casting is made. Die castings do not have surface pits and can be buffed to a high luster. Pits in sand castings make buffing impractical.



REDUCTION in assembly time of this clutch driver assembly was from 30 per 8 hr to 30 per hr after modification for induction brazing. This change consisted entirely of adopting close tolerances on the clearance between the holes and the pins.



GRAPH gives approximate clearances between flat or tubular parts for brazing with silver solder. All clearances should be held between 0.001 to 0.003 in. Closer values restrict metal flow and result in no bond between the parts, while larger valves provide too much space for the brazing alloy to fill. Curve above is based on joint of stainless steel to stainless steel, but differs little for other materials.



STEP-BY-STEP VIEWS of front fork assembly illustrate use of solder rings in motorcycle manufacture. Formerly, a groove was machined in the lower fitting for the solder ring. However, the joint leaked and came loose. Now, the silver solder ring is placed at the top of the bracket, and capillary action pulls the metal into the joint. Flux is used for all joints in this assembly.

Better Use of Phenolics Basis of Breaker Redesign

Correct application of wood-flour-filled phenolic compound simplified quantity production and improved performance in these small General Electric Company circuit breakers. Used for the protection of distribution transformers, they are rated from 1½ to 10 kva. Simplicity of manufacture, accuracy and reliability in operation was made possible by the following design techniques:

1. Designing the molded parts so that simply shaped metal parts can be used with them.

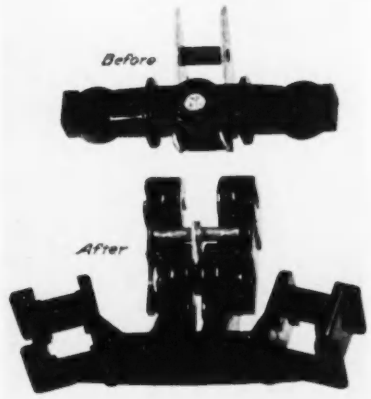
2. Elimination of inserts.

3. Designing molded parts so that no cross pins or wedges are required in the molds.

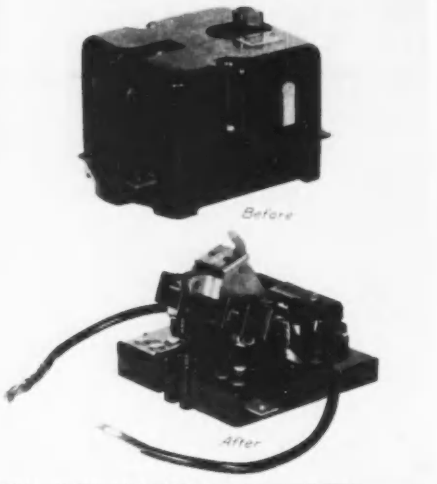
4. Elimination of machining operations on molded parts.

5. Avoiding small or long slender pins in the molds, reducing molding time and mold maintenance.

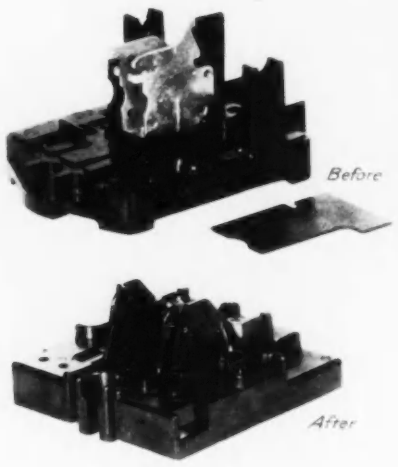
Use of molded parts in the new breaker has resulted in an improvement in quality. Important dimensions can be held accurately, producing consistency of operation. Where bearing holds have been designed into the molded parts, excellent surface finish as well as low coefficient of friction and long bearing life is obtained.



GREATER COMPLICATION of the new part allows the use of simpler metal parts that are assembled to it, and makes possible a saving in assembly time. The intentional designing of intricacies in the molded parts where the cost is less eliminates additional parts used on the old breaker and provides a more rugged cross arm and contact assembly. A bimetallic mechanism trips the circuit breaker on overload.



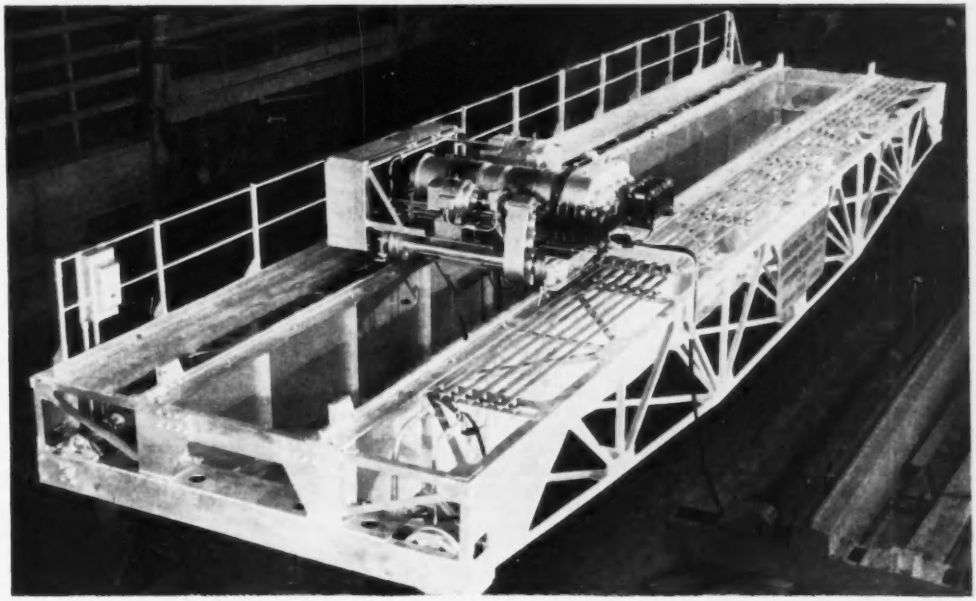
IN THE OLD DESIGN, circulation of oil around the bimetals was restricted by the use of a molded cover to produce the proper tripping characteristic. In the new design, this was accomplished by mounting the bimetals in a cavity on the underside of the breaker base. Since the breaker is mounted inside of a sealed transformer tank, the breaker cover served no other useful purpose, and was eliminated by proper design of the new base. The Air Circuit Breaker Division of G.E. is in Philadelphia.



MOLDED BASE, mechanism framer and laminted compound insulating bariers of the former model are compared with the new molded base. The single new molded base replaces the four pieces used in the old design. Necessary accuracy and complete uniformity of equipment can be obtained by the use of molded parts. Recesses are provided in the molded parts for the mechanism pins. No additional machining is done. Side openings through the base are molded by offsetting the mold cavity and plunger.

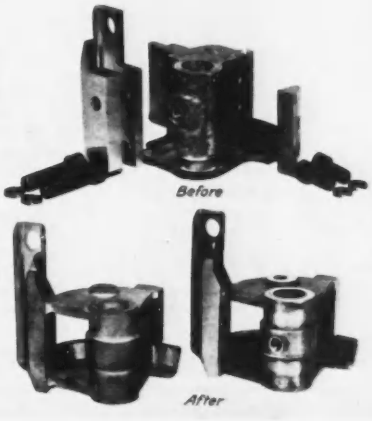
Aluminum Crane Requires Less Hp

The entire structure of this overhead travelling crane is of welded aluminum construction. Heat treated 65 ST alloy is used even for girders, end trucks, walkway, handrail (usually steel) and bridge conductors (usually copper). Girder web plates are rolled and all other sections extruded. The material change enabled the manufacturer, Provincial Engineering Company of Niagara Falls, Canada, to reduce the drive motor size by 5 hp. The aluminum crane costs more than an equivalent steel crane. But economies to the user offset this. The supporting structure for the aluminum crane — runway rails, pillars, etc.—are less expensive since they carry a lighter load. Power costs and rail maintenance are less.



Investment Casting Saves 57 Operations

Machining was the major cost item in the production of this shuttle lifter for a weaving machine. A total of 77 separate operations were involved. The Warner and Swasey Co. of Cleveland eliminated 57 of these operations by redesigning the part for precision investment casting. The shuttle lifter is cast as one piece and requires only 20 operations for completion. Labor savings are considerable. Machining takes 0.834 hr as compared with 2.899 hr for the original design. There are other cost savings. Less material is needed for the part since less is cut away. Also, there is a reduction in stocking and handling since fewer parts are used. Precision Metalsmiths, Inc., Cleveland, does the casting.



Probability Methods
For Establishing Tolerances

How to reduce allowances for the accumulation of tolerances without losing control of the number of rejections in the shop.

M. D. BARROWS
General Electric Company

OVERALL DIMENSIONAL TOLERANCES calculated by methods using the laws of probability are smaller than those calculated by conventional methods. The use of the laws of probability instead of conventional methods can reduce manufacturing costs in any of three ways:

(1) Savings of material made
(2) Liberalization of tolerances accomplished
(3) Percentage of rejections controlled

The usual way to get the over-all dimensional tolerance is to add up the tolerances of the individual parts. Tolerance limits so computed provide for the extreme cases in which all the components are either as long or as short as their individual tolerances permit. Obviously, these extreme combinations are infrequent, and a considerably smaller tolerance can be established if the designer is willing to risk having a small fraction of the completed assemblies fail to meet specifications. A rational basis for establishing this new tolerance without losing control of the number of rejects has been developed through use of the laws of probability.

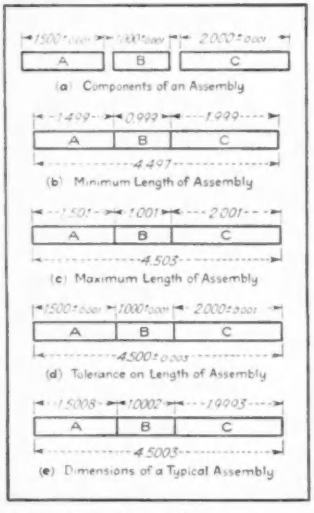


Fig. 1—Accumulation of tolerances.

The manner in which tolerances accumulate is illustrated in Fig. 1. In this figure is shown an assembly consisting of the three parts of Fig. 1(a) laid end to end. If each of these parts were as short as its tolerances permitted, the assembly would have its minimum possible length, 4.497 in. as shown in Fig. 1(b). On the other hand, if each part should have its maximum permissable length, the assembly would have its maximum possible length, 4.503 in. shown in Fig. 1(c). Therefore, the assembly can be either greater or less than 4.500 in. by the amount 0.003 in. This is expressed by writing the over-all length as 4.500 ± 0.003 in. as shown in Fig. 1(d).

Actually, the length of the assembly is not very likely to deviate from 4.500 in. by as much as 0.003 in. Usually, when some of the parts are longer than the nominal length, others are shorter. Furthermore, the individual parts do not usually deviate from their nominal length by nearly as much as their tolerances permit. The combined effect of these factors is illustrated in Fig. 1(e). Parts A and B are longer their nominal length while part C is shorter. In addition the deviation of part B from the nominal length is small compared to the deviation permitted by the tolerance. The net result is that the over-all length 4.5003 in. differs from the nominal over-all length by only one tenth the amount allowed by the over-all tolerance.

A calculation based on the laws of probability estimates that, if the over-all tolerance were reduced to ± 0.0017, 99.7 percent of the assemblies would be within that tolerance. The formula for calculating this reduced tolerance is given below. However, its presentation will be preceded by an explanation of probability distribution curves.

Probability Distribution Curves

The probability of an event is the fraction of the possible occurences thereof estimated to take place. In analysis of tolerances, the probability that the length of a given dimension will fall within a specified range is frequently of importance.

As an example, consider a part made to a nominal length of 1,000 in. It is possible, but not certain, that the length lies in the range between 1.000 and 1.0002 in. The probability that the length lies in the range between 1.0000 and 1.0002 in. is the fraction of parts estimated to have lengths within that range.

In dealing with tolerances, it frequently is necessary to consider the probabilities of several ranges of lengths simultaneously. The above mentioned part might be made so that its length could not be less than 0.9990 or more than 1.0010 in. In this case the actual length could fall in any of ten possible ranges each of length 0.0002 in. Associated with each of these ranges is the probability of the length falling within that range.

A graph known as a histogram is used in Fig. 2(a) to represent these probabilities. Along the horizontal axis, the possible ranges of values of length are laid off. Each of these ranges is used as the base of a rectangle whose area equals the probability that the length will be within that range. The numerical value of this area is given by the number in or near the rectangle. Instead of dividing the possible lengths into ranges of 0.0002 in., division into ranges of 0.0001 in. is possible. The histogram for those shorter ranges is shown in Fig. 2(b). Making the ranges smaller and smaller would make the upper outline of the histogram become more and more like the curve shown in Fig. 2(c). Between any two values of actual length, the area under the curve equals the probability of an actual length between those two values. Because of this

relationship between area and probability, the curve is known as a probability distribution curve.

In this article, formulas based on two types of probability distribution curve are used. The first type of curve, known as the Normal Law, is illustrated in Fig. 2(c). Probability distributions in many fields have been found to be in good agreement with the normal law. The second type of curve known as the Rectangular Law is shown Fig. 2(d). Here the height of the curve is the same throughout the range of possible values of X and zero elsewhere.

Probability Tolerance Formulas

The tolerances for an assembly calculated by the formula given below are expected to be satisfied 99.7 percent of the time. Because of the complexity of the mathematics involved, their actual derivation will not be given. Instead the explanation below will be limited to an indication of the steps involved in deriving the formulas, a statement of the formulas themselves, and a reference to a source of further information on the derivation.

The first step is the determination of the probability distribution curves for the component parts of the assembly. One way of getting these would be to measure a large number of parts. The information thus obtained could be used to estimate the probability distribution curve. Since this method is laborious and since results cannot be obtained before the parts are made, it is fortunate that other methods are available. These methods are the approximation of the actual distribution by either the Normal Law or by the Rectangular Law.

When the parts are made in quantity, the Normal Law is usually a good approximation of the actual probability distribution curve. When the shop is aiming for the middle of the tolerance range this approximation is not likely to be seriously in error. Therefore, when the Normal Law is used, it is desirable to take the following precautions:

(1) Set close tolerances on the parts. The actual tolerance will depend upon the process or machining method used. The machine set-up man will then aim for the nominal length to avoid excessive rejections.

(2) Arrange for sufficient inspection to make sure manufacturing set-ups are aimed for the nominal length.

When only a small number of parts are made, the more conservative Rectangular Law should be used. Here again, the shop should aim for the

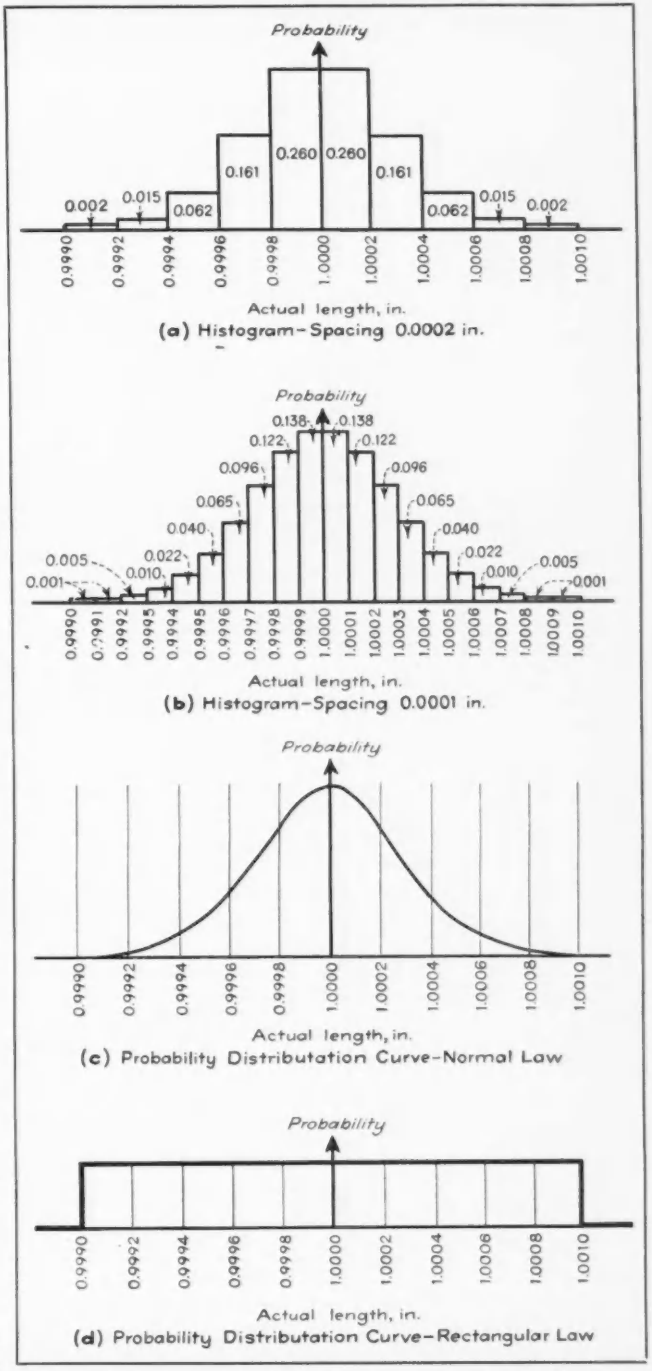


Fig. 2—Graphical representation of normal and rectangular probability distributions.

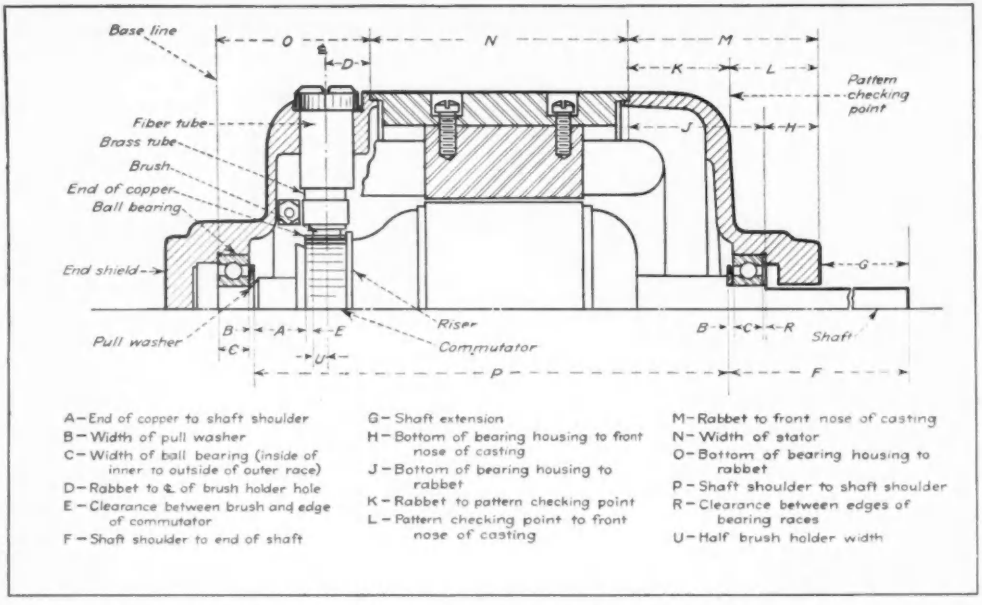


Fig. 3—Internal construction of a commutator motor showing both the over-all dimensions and the dimensions of the components.

middle of the tolerance range.

The probability distribution curves for the parts can be combined to get the probability distribution curve for the assembly. The manner in which probability distribution curves are combined is discussed in the 1942 AIEE paper by Roger I. Wilkinson, "The Combination of Probability Curves in Engineering". The combination of rectangular probability distribution curves is discussed in unpublished papers by M. L. Schmidt a design engineer associated with the General Electric Company.

When the probability distribution curve for the assembly is known, the tolerance for the assembly can be calculated. The tolerance is then taken as the range of values of length for which the probability is 0.997.

When the distribution curves for the parts are approximated by either the Normal Law or the Rectangular Law, a simple formula expresses the tolerance of the assembly in terms of the tolerances of the parts. To establish a notation for tolerance formulas, let

T_1 = Total tolerance range of length of part 1

T_2 = Total tolerance range of length of Part 2

. . . . . .

T_n = Total tolerance range of length of Part n. Also, let S be an assembly the length of which is the sum of the length of parts 1, 2, · · · , n. Then let

T_s = Total tolerance range of length of assembly S.

Using this notation, the Normal Law Tolerance Formula is:

$$T_s = \sqrt{T_1^2 + T_2^2 + \cdots + T_n^2} \qquad (1)$$

and the Rectangular Law Tolerance Formula is

$$T_s = T_1 + T_2 + \cdots + T_n - 2\sqrt{0.001\,(n!) \times \sqrt{T_1 \times T_2 \times \cdots \times T_n}} \qquad (2)$$

Applications of Normal Law Tolerance Formula

In Fig. 3 is shown a drawing of a typical commutator motor. The dimensions affecting commutator length for brush ride, shaft extension, and end play are labled.

COMMUTATOR CLEARANCE. One of the manufacturing requirements is that the dimension E, the clearance between brush and edge of commutator should never be less than zero, Let

θ = Eccentricity of inside of fibre tube to outside of fiber tube

ϕ = Eccentricity of inside of brass tube to outside of brass tube

Then

$$E = O - A - B - C - D - U \pm \theta \pm \phi$$

Let T_A = Total possible tolerance range of $A = 0.060$ in.

T_B = Total possible tolerance range of $B = 0.020$ in.

T_C = Total possible tolerance range of $C = 0.010$ in.

T_D = Total possible tolerance range of $D = 0.020$ in.

T_o = Total possible tolerance range of $O = 0.020$ in.

T_θ = Total possible tolerance range of $\theta = 0.004$ in.

T_ϕ = Total possible tolerance range of $\phi = 0.004$ in.

The dimension U is considered exact.

Addition of these tolerance ranges shows that the possible values of E have a total range of 0.138 in. Therefore, the actual length of the dimension E can differ from its nominal value by $\pm$ 0.069 in. However, the Normal Law Tolerance Formula gives a probable total tolerance range of

$$\begin{aligned} T_E &= [T_A^2 + T_B^2 + T_C^2 + T_D^2 + T_o^2 + T_\theta^2 + T_\phi^2]^{1/2} \\ &= [(0.060)^2 + (0.020)^2 + (0.010)^2 + (0.020)^2 + (0.020)^2 + (0.004)^2 + (0.004)^2]^{1/2} \\ &= 0.070 \text{ in.} \end{aligned}$$

In other words, an estimated 99.7 per cent of the motors produced will have a value of the dimension E differing from the nominal value by $\pm$0.035 in. or less.

SHAFT EXTENSION. The dimension G, or shaft extension, is calculated by the formula:

$$G = C + B + P + F - O - N - K - L$$

The total tolerance ranges not already given under the discussion of commutator clearance are

T_N = Total possible tolerance range of $N = 0.020$ in.
T_K = Total possible tolerance range of $K = 0.020$ in.
T_L = Total possible tolerance range of $L = 0.060$ in.
T_F = Total possible tolerance range of $F = 0.020$ in.
T_P = Total possible tolerance range of $P = 0.010$ in.

From addition of the total tolerance ranges of G, B, P, F, O, N, K, and L, it can be seen that the possible total tolerance is 0.180 in. In other words, the dimension G may deviate from its nominal value by plus or minus 0.090 in. However, according to the Normal Law Tolerance Formula, the total tolerance range satisfied by 99.7 percent of the assemblies is:

$$T_G = [T_N^2 + T_L^2 + T_P^2 + T_F^2 + T_O^2 + T_N^2 + T_K^2 + T_L^2]^{\frac{1}{2}} = 0.076 \text{ in.}$$

Thus in an estimated 99.7 percent of the motors made, the dimension G will not deviate from its nominal value by more than ± 0.038 inches.

END PLAY. The dimension R is a space allowed for the tolerances in the other dimensions. This dimension must satisfy the relationship

$$R = O + N + J - [2C + 2B + P]$$

The difference

$$R - [O + N + J] + [2C + 2B + P]$$

must be taken up by shims.

The total possible tolerance range T_J of J is 0.020 inches.

The total tolerance ranges of the other dimensions have already been given. Addition of the tolerances shows that R can vary by as much as ± 0.065 in. Application of the Normal Law Tolerance Formula gives the following total tolerance range, which is expected to be satisfied by 99.7 percent of all assemblies

$$T_R = [T_O^2 + T_N^2 + T_J^2 + 2T_C^2 + 2T_B^2 + T_P^2]^{\frac{1}{2}} = 0.048 \text{ in.}$$

In other words 99.7 percent of the assemblies are expected to have a dimension R differing from the nominal value by 0.024 in. or less.

Application of Rectangular Law Tolerance Formula

To show how the Rectangular Law Tolerance Formula is used, it will be applied to the problems of commutator clearance. The formula for calculating this dimension in terms of other dimensions has already been given in the treatment of this problem by the Normal Law Tolerance Formula. The tolerance in E is, according to the Rectangular Law Tolerance Formula:

$$T_E = T_A + T_B + T_C + T_D + T_a + T_\theta + T_\phi - 2\sqrt[7]{(0.001)^{(7!)}} \times \sqrt[7]{T_A T_B T_C T_D T_a T_\theta T_\phi} = 0.104 \text{ in.}$$

Hence, the dimension E is not expected to deviate from its nominal value by more than $\pm$ 0.052 inches.

Advantages of Probability Method

In the problem of commutator clearance, it is necessary to make the usable length of the commutator equal to the width of the brush plus the total tolerance range of the dimension E. In this way the brush will not extend beyond the end of the commutator or interfere with the riser as long as the dimension E satisfies its tolerance. When the brush width is 0.250 in., the commutator length is calculated from the total tolerance range in accordance with the following table:

Tolerance Computation Method	Total Tolerance Range, in.	Usable Commutator Length, in.
Addition of tolerances	0.138	0.388
Rectangular distribution law	0.104	0.357
Normal distribution law	0.070	0.320

Using the normal law instead of simple addition leads to a 20 percent saving in commutator length and hence in commutator material.

Instead of changing the required usable commutator length, the use of probability methods could lead to larger permissable tolerances without a change in the required commutator length.

These changes in required usable commutator length or in the tightness of the tolerances are based on rational computations. By using rational computations rather than cut and try methods, control of the percentage of rejected assemblies is maintained.

Properties of Magnesium Alloy Systems Studied

A COMPREHENSIVE SURVEY of the mechanical properties of some 200 alloys in forty magnesium alloy systems reveals that, of those systems studied, magnesium-zinc-manganese-calcium is the most promising combination for further study and development. These studies are fully discussed in a report released by the Office of Technical Services of the U. S. Department of Commerce.

The study, undertaken by Rensselaer Polytechnic Institute for the Air Force, disproved certain favorable assumptions that had been made regarding the high mechanical strength and good workability of German Giesche alloy. Data also indicated that the addition of 5 percent each of the intermetallic compounds Cd_3Ni_8, Cd_3Cu, and Cd_3Sb_2 failed to improve the mechanical properties of magnesium and magnesium-zinc base compositions.

A preliminary investigation of warm rolling procedures for dilute magnesium-base alloys indicated the possibility of increased ductility and toughness with moderate strength properties through these methods, although the data were too limited in scope to draw specific conclusions.

Further study of the magnesium-zinc-aluminum-tin system agreed with earlier results indicating that magnesium-5, zinc-3, aluminum-3 tin was the best combination of this particular specialized system.

The promising magnesium-5, zinc-1, silver-1.5, manganese-0.3 calcium alloy still has the drawbacks of hot-shortness (tendency to break under stress when being handled under high temperature) and extreme sensitivity of its mechanical properties to small variations in composition and handling procedures.

Report PB 97657, *New Magnesium Alloys*, 243 pages including photographs, tables and bibliography, sells for $31.25 in photostat, $9.00 in microfilm. Orders should be addressed to the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C., accompanied by check or money order payable to the Librarian of Congress.

Fig. 1—Bearings and materials are compared in this fatigue testing machine. Oil is supplied through drilled shaft.

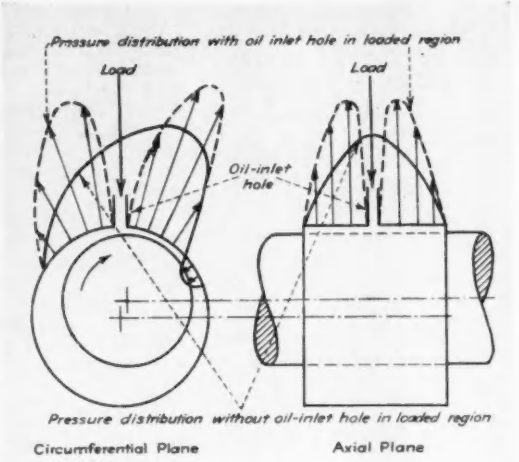


Fig. 2—Effect of placing the oil-inlet hole in the loaded region of a journal bearing is to force oil out of the hole rather than draw it in.

Oil-Inlet Holes and Grooves For Journal Bearing Lubrication

A. E. ROACH and C. B. GRIFFIN
Research Laboratories Division, General Motors Corporation

Second in a fundamental series on journal bearing lubrication, this article describes the location of oil-inlet holes, and oil grooving for hydrodynamic lubrication and partial-film lubrication. Dimensions and shapes are recommended.

DISTRIBUTION OF OIL FILM PRESSURE in a bearing is the criterion for correct location and design of oil-inlet holes and oil grooves. In the first article of this series (PRODUCT ENGINEERING, October 1949, page 126) it was shown that in the circumferential plane of a journal bearing, oil film pressure increases as the clearance space converges, reaches a maximum near the point of minimum clearance, and then decreases sharply as the clearance space diverges until it reaches atmospheric or possibly slightly less than atmospheric pressure. In the axial plane, the oil film pressure curve is approximately parabolic, having its maximum value along the centerline of the bearing and decreasing on either side of this centerline until, at the ends of the bearing, it falls to atmospheric pressure. Therefore there is a three dimensional pressure "hump" the resultant of which is an internal force on the bearing surfaces, equal in magnitude but opposite in direction to the external load on the bearing.

If oil is to be supplied to a bearing through an oil-inlet hole, the hole should be located in the unloaded part of the bearing where the clearance is large and the oil film pressure is low. To take advantage of "natural" suction, the oil hole can even be located in the region of negative pressure, which in some bearings is sufficient to lift the oil through a tube for a distance of 2 or 3 inches.

The oil-inlet hole should not be placed in the loaded part of the bearing; otherwise, the oil will be forced out of the hole rather than drawn in, thus robbing the bearing of oil where it is most needed. The pressure hump becomes dimpled, as shown in Fig. 2, since the pressure drops to atmospheric at this point. The surfaces, no longer separated by an uninterrupted high-pressure oil film, come closer together, and the danger of partial-film friction or complete seizure is greatly increased. In addition, since the internal force of oil film pressure on the bearing surfaces must still equal the external load, the peaks of the pressure humps must be intensified. This places the bearing material under greater stress and effectively shortens its fatigue life.

The same conclusions apply to oil grooves. Grooves, if they are used, should be located in the low-pressure region, never in the high-pressure region, except in a few special cases which will be discussed. An oil groove

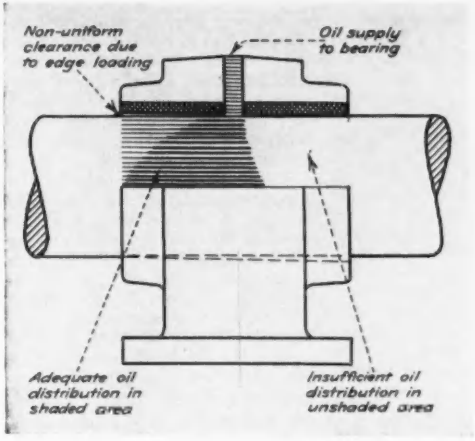

Non-uniform clearance due to edge loading
Oil supply to bearing
Adequate oil distribution in shaded area
Insufficient oil distribution in unshaded area

Fig. 3—Any variation in clearance caused by tapering or edge loading of a bearing without an axial distributing groove will result in uneven distribution of oil in the bearing.

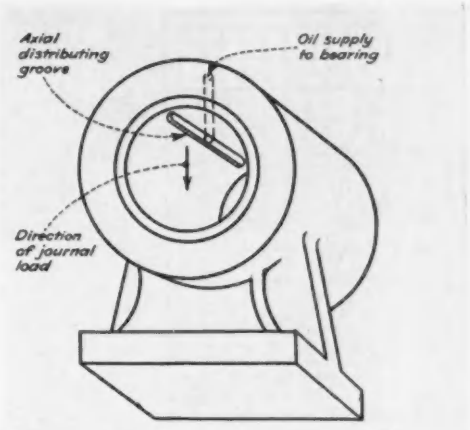


Fig. 4—Axial distributing groove that communicates with the oil inlet hole alleviates uneven distribution of oil. Groove should be stopped off short distance from end to prevent leaks.

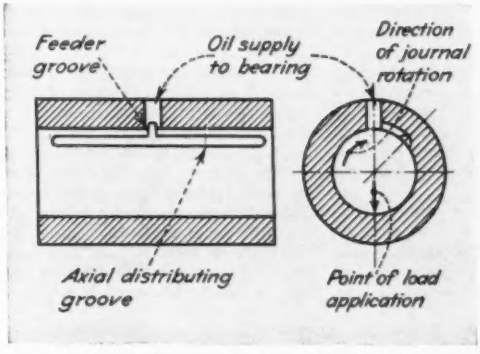


Fig. 5—Axial distributing groove with feeder groove improves performance of large diameter, slow speed bearings.

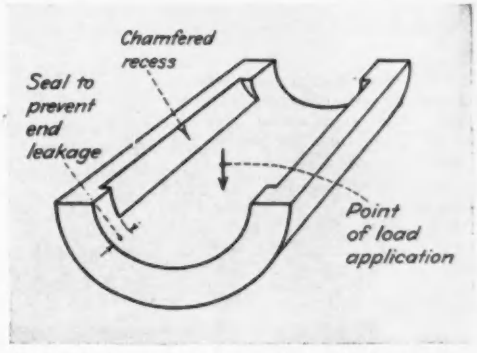


Fig. 6—Chamfered recess makes an effective distributing groove at parting line of split bearing, and prevents projecting edges.

should not extend to the ends of the bearing but should stop short, so that the unrelieved material at the edge can act as a dam to prevent excessive leakage. As a general rule, the less grooving the better, and frequently no grooving at all is the best practice.

Oil Grooving for Hydrodynamic Lubrication

TO ASSIST AXIAL DISTRIBUTION. In a bearing with a simple oil-inlet hole, as shown in Fig. 3, any variation in clearance caused by tapering of the bearing or journal or by edge loading will result in uneven distribution of oil in the bearing, since the oil will follow the path of least resistance. This can be prevented by providing an axial groove that communicates with the oil-inlet hole, as shown in Fig. 4. This groove should be stopped off a short distance from the end of the bearing to prevent excessive leakage. For bearings 1 to 2 in. in diameter, Willi recommends a sealing distance of ¼-in. from the end of the groove to the edge of the bearing. For bearings 3 in. in diameter and over, ½ in. is recommended.

With large diameter bearings (over 2½ in.) which operate at slow speed (below 25 fpm) the distance between an oil-inlet hole located at the top center and the high-pressure area near bottom center can be so great, that there is leakage enroute and an insufficient supply of oil reaches the pressure area. Increasing the oil supply by introducing oil under pressure is the recommended remedy, but if this is not feasible, performance can sometimes be improved by moving the distributing groove in the direction of shaft rotation towards the point of load application, as shown in Fig. 5. The groove should not be located in the high-pressure area; a recommended location is 30 degrees ahead of the beginning of the high-pressure area. The groove must be supplied with oil through a short circumferential feeder groove connecting with the oil-inlet hole. Since the feeder groove should always feed in the direction of journal turning, this type of grooving is applicable only to bearings in which there is no reversal of rotation, and in which the load is unidirectional.

For split bearings, an effective distributing groove can be obtained by chamfering a recess at the parting line of the bearing halves, as shown in Fig. 6. Such a chamfered recess assists axial distribution of the oil film,

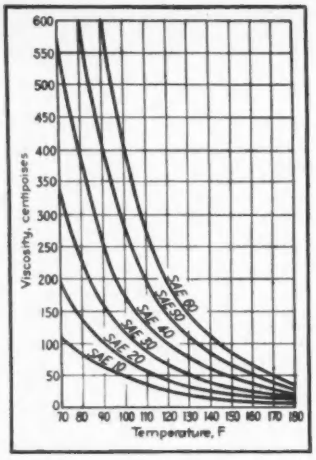


Fig. 7—Viscosity of mineral oils decreases markedly with temperature. Since the film becomes thinner, excess quantities of oil must be supplied to carry away the heat. If not, partial-film friction may result.

and—equally important—it insures against the possibility of projecting sharp edges which act as scrappers, removing oil from the journal and breaking the oil film.

TO COOL THE BEARING. The work done in overcoming the internal friction (viscosity) of an oil film is transformed into heat, and the heat produced is proportional to the work done. If H is the heat in Btu per min produced in the bearing, then

$$H = \frac{W f v}{778}$$

where W is the load on the bearing in lb, f is the friction coefficient, and v is the surface velocity in fpm. Since the volume of oil in the bearing is very small, the temperature rise in the film may be considerable. The viscosity of mineral oils decreases markedly with increase in temperature, Fig. 7, resulting in the film becoming thinner and increased danger of partial-film friction and seizure. However, when viscosity of the oil film decreases from heating, the work required to overcome viscous friction and the heat produced also decrease. If equilibrium between the rate of heat generation and the rate of heat dissipation is attained before a partial-film condition is reached, the bearing will continue to run under stable conditions on an oil film of diminished thickness and viscosity. Some automatic compensation for heating is thus provided.

One way to avoid partial-film friction and seizure from heating is to provide the bearing with a supply of oil in excess of that required for lubrication purposes. The excess oil then serves as a coolant to carry away the heat.

To insure rapid and complete circulation of the coolant oil through the bearing, a circumferential or annular groove can be provided, as shown in Fig. 8. Although this type of groove reduces the projected bearing area, and in effect splits the bearing into two bearings of reduced width, resulting in higher peak pressures in the oil film, such a bearing will frequently function longer and better than an ungrooved bearing with considerably lighter loads.

It is common practice to extend the annular groove completely around the bearing. A study of oil grooves undertaken by Clayton indicates that this is not necessary and may not even be desirable, when there is no reversal of rotation. Clayton reported that the oil flow was increased with increasing groove arc up to about 90 degrees as measured from the oil-inlet hole. When the groove was extended beyond 90 degrees, however, the flow was slightly reduced until an arc of 270 degrees was reached. There was no appreciable change in the flow from 270 to 360 degrees.

TO MINIMIZE OIL FILM INSTABILITY. The essential requirement for hydrodynamic lubrication—that the journal be located eccentrically in the bearing to form a converging oil film—leads to an inherent instability. The rate at which oil is dragged through any cross section of the bearing is roughly proportional to the clearance at that point. This means that less oil is dragged through the minimum clearance than was dragged into the converging clearance space before it. The excess oil must be accommodated either by axial leakage, or by displacing the journal ahead of it to open

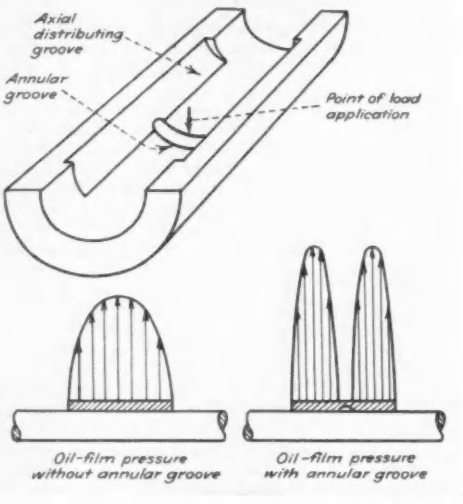


Fig. 8—A circumferential or annular groove promotes oil film cooling. Although bearing area is reduced, life is improved.

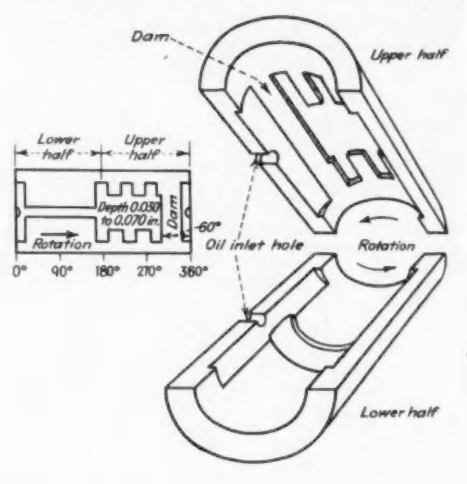


Fig. 9—To minimize oil film instability dam type of oil grooving reduces bulk movement of oil over face of non-whirling bearing.

Table I—Recommended Dimensions for Oil Grooves

Bearing dia, in.	Width, in.	Depth, in.
1/2-1	9/64	3/64
1-1 1/2	3/16	1/16
1 1/2-2 1/2	9/32	3/32
2 1/2-4	3/8	1/8
4-5 1/2	9/16	3/16

up the volume required by this oil.

At most speeds displacement of the journal is restrained by the load on it, and oil volume requirement is adjusted entirely by axial leakage. At twice critical shaft speed, however, the average speed of the oil film and the speed of elastic vibration of the shaft coincide, making possible a resonant combination of the oil film force and the elastic force, particularly under light loads. The journal center is then forced to rotate about the bearing center at oil film speed, allowing no relative movement between journal and oil film to maintain hydrodynamic action. The oil film pressure falls to zero, and the bearing and journal rub against each other without an intervening oil film.

The recommended remedy for this condition is to design the shaft so that its critical speed is well above half running speed. Where this is not possible some relief may be had by using a special type of oil grooving, developed by Newkirk and Grobel, and illustrated in Fig. 9. The principle is to erect a dam in the path of the oil film, to minimize bulk movement of the oil over the face of the bearing. The deleterious effect of the grooving on the continuity of the oil film is preferred to the complete bearing failure that would otherwise result. For a full discussion of this grooving theory, see the paper by Newkirk and Grobel listed in references.

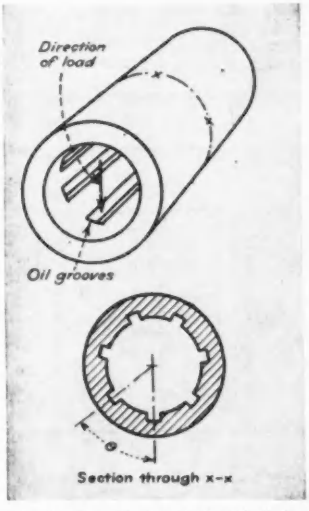


Fig. 10—For pulsating load with limited journal rotation, this oil grooving arrangement is suitable.

Oil Grooving for Partial-Film Lubrication

It is not yet possible to set hard-and-fast rules for grooving bearings that must operate under partial-film conditions. Partial-film lubrication apparently depends on a chemical reaction between the lubricant and bearing metal rather than on any definite oil film pressure effect; thus, it may little matter whether the groove cuts across the loaded region of the bearing, although such a groove reduces the effective load-supporting area of the bearing and thus contributes to partial-film friction. Some authorities recommend elaborate grooves—such as "Figure 8", criss-cross grooves, and the like—in the loaded region. Others recommend no grooving at all. In any event, the objective is that there shall be at least a thin film of oil throughout the bearing.

Where there is a variable oil supply to a bearing, such as is obtained with hand oiling, the running condition of the bearing may range from full-film to partial-film, depending on the interval between oil applications. A similar condition can result with lubricating devices such as drop-feed and wick-feed oilers, in which the quantity of oil supplied depends on its height in the reservoir of the oiler. Such varying conditions of oil supply impose a special design problem, in respect to oil grooves. To take advantage of full-film conditions when the oil supply is adequate, grooving should be held to a minimum. However, oil must be supplied close to the loaded region, to maintain an oil film when partial-film conditions prevail.

The grooving arangement shown in Fig. 10 is useful where the load pulsates between positive limits in one direction and the journal turns only a few degrees between successive load pulses. In such a situation as in the wrist-pin bushing of a two-stroke cycle engine, the grooves must be so spaced that the journal can pick up a fresh supply of oil for each load pulse. If the journal turns θ degrees between load pulses, the grooves should be located at intervals of θ degrees around the bearing. The fact that the grooves occur in the loaded region is of little consequence, since the journal turns so slowly that hydrodynamic action cannot be sustained. Such an arrangement is applicable only where there is always some positive unidirectional load; where the load direction reverses such grooves serve no useful purpose.

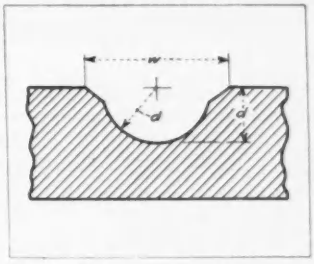


Fig. 11—Oil grooves should be semi-circular in cross-section and chamfered at the edges (see Table I for recommended dimensions). Vertical sides should be avoided.

Design of Oil Grooves

Oil grooves should be semi-circular in cross section and chamfered at the edges, as shown in Fig. 11. Table I gives oil groove dimensions recommended by Clower. Deep, vertical-sided grooves act as scrappers to remove oil from the journal surface and are therefore to be avoided. V-shaped grooves are also objectionable, since the V provides a stress riser from which a fatigue crack may start in the bearing.

EDITOR'S NOTE: The concluding article of this series, to appear in the December issue of PRODUCT ENGINEERING, will cover the design and application of various devices for supplying oil to a bearing, and the effect of such devices on friction characteristics, service requirements and reliability of the bearing.

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Assembling Radial-Thrust Bearings

Twenty-four possibilities to consider exploring

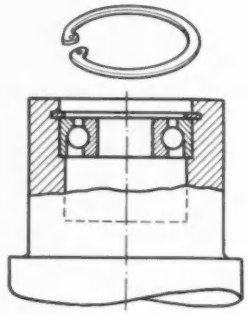

Fig. 1 - Retainer ring holds the bearing in place on the shaft.

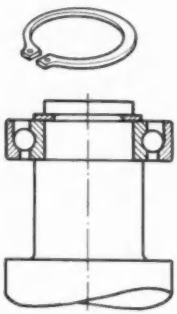

Fig. 2 - Split flange can be assembled after bearing is mounted.

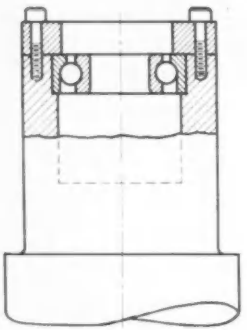

Fig. 3 - Flange is fastened with screws to the shaft.

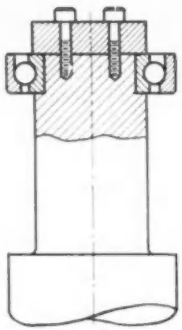

Fig. 4 - Flange is keyed on the shaft to support the bearing.

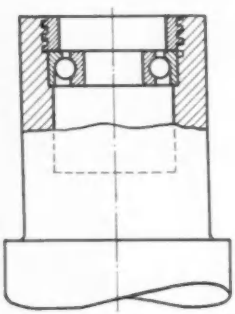

Fig. 5 - Flange is screwed on the shaft to support the bearing.

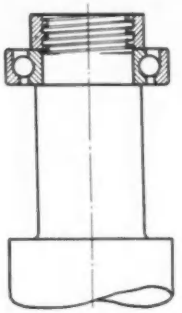

Fig. 6 - Flange is screwed on the shaft to support the bearing.

on Shafts with Blind Ends

when confronted with rigid requirements.

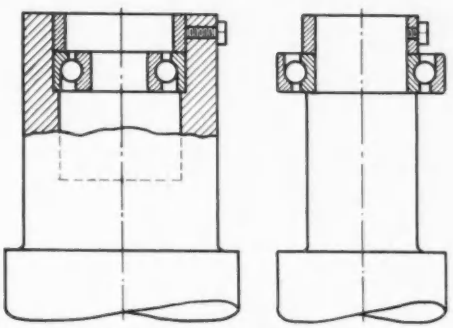

Fig.7-Flange is fastened to the shaft by set screw.

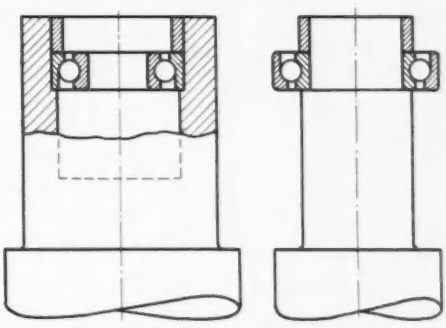

Fig.8 - Flange is fastened to the shaft by shrink fit.

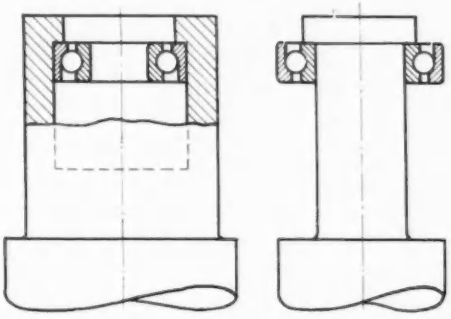

Fig.9-Flange end is welded or upset after assembly of bearing race

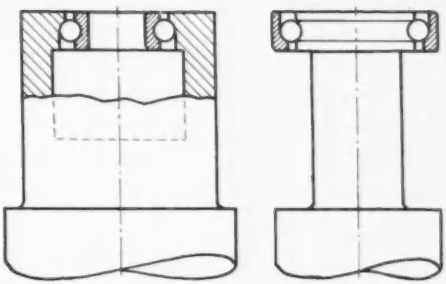

Fig.10-Bearing race is constructed integral with shaft.

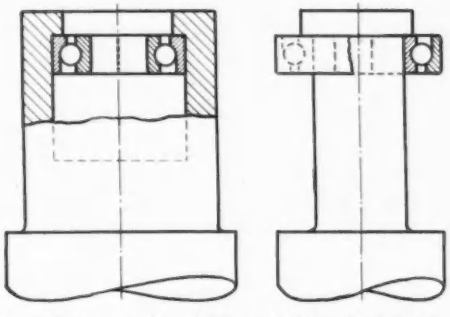

Fig.11-Bearing race is split. Flange is integral with shaft

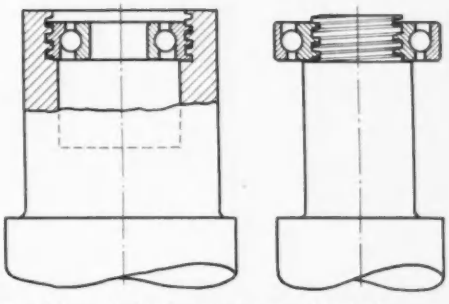

Fig.12-Threaded bearing race screws on the shaft.

BUCKLING

Of Uniform and Stepped Columns—II

- Factor of safety, initial eccentricity and fatigue stress considerations in determining the critical load.
- Buckling of cylinder and piston-rod assemblies.
- Examples of the method described applied to various buckling problems, also analysis of effect of dimensional changes.

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Research Engineer
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HANDBOOK FORMULAS for buckling must represent a compromise to suit many applications. A method for more accurate investigation of buckling, including buckling of single-stepped columns, was presented last month in the first article of this two-part series. That article included (1) the analytical procedure, (2) curves for finding the critical load when initial eccentricity and cross section shape are taken into account, and (3) a method for rapidly determining the length of a uniform cross section bar that is equivalent in elastic behavior to a pin-jointed, single step column. The reader should consult Part I for the procedures, graphs, and figures referred to in the discussion and examples that follow.

Factor of Safety
Initial Eccentricity
Consideration of Fatigue Stresses

For buckling problems to which Handbook formulas do not readily apply, it is recommended that the critical load be calculated as outlined in Part I, PRODUCT ENGINEERING, Oct. 1949, p. 119. The desired factor of safety should then be applied to the critical load in order to establish the working load, that is

$$P_{working} = \frac{P_{critical}}{F} \qquad (28)$$

Since the extreme fiber stress increases more rapidly than the compressive force (see Figs. 2 to 7 in Part I and recall that the compressive force is proportional to the average compression stress), the factor of safety with respect to the extreme fiber stress is generally greater than with respect to the compressive force. The proper choice of the factor of safety requires considerable engineering judgment. The influences to be considered are:

1. Importance of the compression member and consequences in case of its failure.
2. Accuracy in determining the maximum load.
3. Material properties.
4. Initial eccentricity.

The first two factors depend entirely on the particular application. It can only be said that generally a higher factor of safety should be chosen if the column is an important part of the structure and its failure would cause serious damage, and if the loading condition is not known accurately, as when there is a possibility of extraordinary loads.

Material properties, particularly the yield point stress and the modulus of elasticity, are generally known to fair accuracy. Attention should be paid, however, to the possibility of an unusually low yield point resulting from relatively small deviations in composition and/or heat treatment.

The initial eccentricity is difficult to evaluate. It depends on manufacturing accuracy in keeping the columns straight and the pins aligned with respect to the axis of the column. It depends also on the friction that can be developed by the end bearings. The effect of non-homogeneity of the material is equivalent to a certain initial eccentricity and allowance for it is generally made when estimating the initial eccentricity. An initial eccentricity of 0.25 percent of the length of the column is considered a fair assumption for average cases and makes allowance for ordinary imperfections, but this figure should be modified when conditions warrant.

The calculations described in Part I assume sine curves as initial deflection lines of columns or individual parts. This is generally justified, but when it is known that the distribution of bending moments is less favorable (as is the case with a straight column and both end bearings offset in the same direction), a correction should be applied by increasing the assumed initial eccentricity.

When a column is short and heavy and the general conditions permit a low factor of safety with regard to buckling, the calculation may lead to a relatively high extreme fiber stress for the working load. Therefore, a check should be made as to whether the extreme fiber stress under the working load has a sufficient factor of safety with respect to fatigue failure.

Buckling of Cylinder and Piston-Rod Assemblies

Buckling of cylinder and piston-rod assemblies can be calculated by means of the method established, in Part I, for stepped columns. The procedure is sufficiently flexible to take

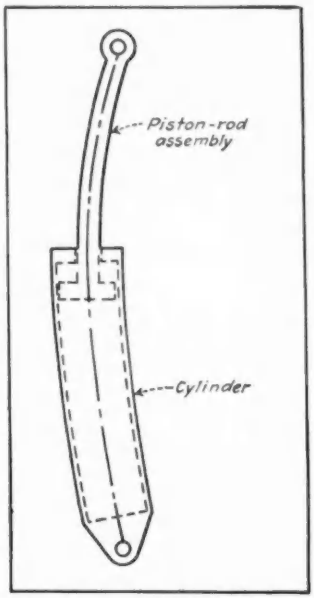

Fig. 10—Increased initial deflection caused by cocking. An appropriate initial eccentricity should be introduced into the buckling calculations for the whole assembly.

care of the particular circumstances encountered.

The critical load is the smallest when the distance between cylinder bearing and piston-rod bearing is at its maximum. In general, only this case needs to be investigated. However, if the force developed by the assembly decreases inherently as the length between pins increases, it is advisable to make the investigation for several combinations of load and length.

Maximum load is determined in most cases by the maximum pressure the pump will deliver or by the setting of the relief valve. Particular attention should be paid to the possibility of the oil volume in the cylinder being kept constant by a "hold position" of the control valve preventing oil flow from cylinder to relief valve. In this event, the maximum load is determined by external factors and may exceed the load corresponding to maximum pressure of pump or relief valve.

In general, the piston rod is less stiff than the cylinder. For the purpose of the buckling calculation it is sufficiently accurate to take the length of the part with the stiffness of the piston rod from the center of the piston-rod pin to the inside of the cylinder gland. The remainder of the length of the assembly then is assigned the stiffness of the cylinder.

The sliding connection between the two components, Fig. 10, generally permits a small angular deflection. This cocking can be taken care of most effectively by introducing an appropriate initial eccentricity into the buckling calculation.

Only a small amount of data is available at present from which to estimate the initial eccentricity to be used for cylinder and piston-rod assemblies. A very limited number of strain gage tests on a new assembly, with little wear in the gland and on the piston, indicated that the initial eccentricity may reach up to 0.4 percent of the fully extended length. It is recommended that the initial eccentricity be determined by electrical strain gage measurements in cases where sufficient data is not available to make a good estimate. Then satisfactory results should be assured.

Application to Types of Buckling Problems

1. Calculation of the Safe Load of an Angle 6 x 6 x $\frac{1}{2}$ in. 12 ft long.

Assume that the yield point of the material is 35,000 psi, that conditions warrant an initial eccentricity assumption of 0.3 percent of the length and that a factor of safety of $F = 1.40$ will be satisfactory. See Table I, Part I, for the Section Constants of this angle.

For the sake of comparison, the calculation will be made for axes 1-1 and 3-3.

	Axis 1–1	Axis 3–3
l = 12 ft	144 in.	144 in.
r	1.86 in.	1.18 in.
l/r	77.42	122.0
z	0.430	0.497
n/z (for n = 0.003)	0.00698	0.00605
For σ_{tot} = 35,000 psi, find from		
Fig. 4, n/z = 0.006, σ =	19,600 psi	12,000 psi
Fig. 5, n/z = 0.008, σ =	17,900 psi	11,000 psi
Interpolate for		
n/z = 0.00698	18,770 psi	
n/z = 0.00605		11,980 psi
Critical Load; P_{cr} = (A = 5.75) σ =	107,900 lb	68,900 lb.
Working Load; $P_{cr}/(F = 1.40)$ =	77,100 lb	49,200 lb
Average Stress under Working Load; $P_{working}/A$	13,410 psi	8,560 psi
For σ = 13,410 and 8,560, find from		
Fig. 4, n/z = 0.006, σ_{tot} =	21,900 psi	20,200 psi
For σ = 13,410 and 8,560, find from		
Fig. 5, n/z = 0.008, σ_{tot} =	24,800 psi	23,600 psi
Interpolate for n/z = 0.00698, σ_{tot} =	23,300 psi	
Interpolate for n/z = 0.00605, σ_{tot} =		20,300 psi

These extreme fiber stresses are relatively high, and if the working load is to be applied frequently, considerations of fatigue failure will dictate a lower working load.

The specifications of the AISC contain two formulas for the working stress of compression members, namely for $l/r \leqq 120$:

$$\sigma_{working} = 17{,}000 - 0.485\,(l/r)^2 \quad \text{(psi)} \qquad (29)$$

and for $l/r \geqq 120$

$$\sigma_{working} = \frac{18{,}000}{1 + \frac{1}{18{,}000}\left(\frac{l}{r}\right)^2} \quad \text{(psi)} \qquad (30)$$

The l/r (slenderness —) ratio of main members is limited to 120, and of secondary members to 200.

Formulas (29) and (30) lead to the following working loads for this column:

	Axis 1–1	Axis 3–3
l/r	77.42	122.00
$\sigma_{working}$	14,090 psi	9,850 psi
Working Load; $(A = 5.75)\ \sigma_{working}$	81,020 lb	56,650 lb

The factor of safety against reaching the yield point stress of this column when designed according to the AISC Formulas is thus

Axis 1–1	107,900/81,020 = 1.33
Axis 3–3	68,900/56,650 = 1.22

There is a noteworthy difference in factor of safety for the two axes, and it is of interest to explore how the individual influences and assumptions affect the factor of safety as determined by the above method. This will be done in the second example, which is to illustrate the influence of l/r, n, and z. These influences are analyzed to acquaint the designer more thoroughly with the problem and not to criticize unduly the AISC formula.

2. Analysis of the Effect of Various Influences on the Safety Factor

a) The Effect of l/r:

Assume solid round bars of 2 in. dia ($A = 3.142$ in.^{2}; $r = 0.50$ in.; $z = 0.5000$) of various length, and initial eccentricity equal to 0.0025 times the respective length. Yield point of the material is 32,000 psi.

l	25 in.	45 in.	60 in.	75 in.	100 in.
l/r	50	90	120	150	200
n/z (0.0025/0.5000)	0.00500	0.00500	0.00500	0.00500	0.00500
For σ_{tot} = 32,000 psi, find from					
Fig. 3, n/z = 0.004, σ =	25,400	18,400	13,400	9,600	5,800
Fig. 4, n/z = 0.005, σ =	23,200	16,100	11,700	8,000	5,400
Interpolate for n/z = 0.00500, σ =	24,300	17,250	12,550	9,100	5,600
Critical Load, $P_{cr} = A\ \sigma$; lb	76,350	54,190	39,430	28,590	17,600
$\sigma_{working}$ by AISC Formula	15,790	13,070	10,000	8,000	5,590
Working Load by AISC Formula; lb	49,610	41,070	31,420	25,130	17,560
P_{cr}/Working Load by AISC Formulas (= Safety Factor of AISC Formulas)	1.539	1.319	1.255	1.144	1.002

b) The Effect of the Initial Eccentricity

Assume a solid round bar of 2 in. dia ($A = 3.142$ in.^{2}) and 50 in. length and determine the critical load for

various initial eccentricities. The yield point stress is 32,000 psi.

Initial Eccentricity, e	0.1 in.	0.2 in.	0.3 in.	0.4 in.	0.5 in.	0.6 in.
$n = e/l$	0.001	0.002	0.003	0.004	0.005	0.006
n/z (for $z = 0.5000$)	0.002	0.004	0.006	0.008	0.010	0.012
σ for $\sigma_{tot} = 32{,}000$ and $l/r = 50/0.50 = 100$	19,600	16,600	14,600	13,100	11,900	10,900
Critical Load, $P_{cr} = A\ \sigma$; lb	61,580	52,150	45,870	41,150	37,380	34,240
$\sigma_{working}$ by AISC Formula	12,150	12,150	12,150	12,150	12,150	12,150
Working Load by AISC Formula	38,180	38,180	38,180	38,180	38,180	38,180
P_{cr}/Working Load by AISC Formula (= Safety Factor of AISC Formula)	1.613	1.366	1.201	1.078	0.979	0.897

c) The Effect of the Section Factor

Consider a 2 in. solid square bar 57.7 in. long and determine its critical load for planes of buckling across flats and across corners. Assume an initial eccentricity ratio $n = 0.0025$ and a yield point of 35,000 psi. $r = 0.577$ in.;

$l/r = 100$	Across Flats	Across Corners
z (from Table I, Part I)	0.5774	0.4083
n/z	0.00433	0.00612
For $\sigma_{tot} = 35{,}000$ psi, find from Fig. 3, $n/z = 0.004$, σ =	17,500 psi	
For $\sigma_{tot} = 35{,}000$ psi, find from Fig. 4, $n/z = 0.006$, σ =	15,500 psi	15,500 psi
For $\sigma_{tot} = 35{,}000$ psi, find from Fig. 5, $n/z = 0.008$, σ =		13,800 psi
Interpolate for $n/z = 0.00433$: σ =	17,170 psi	
Interpolate for $n/z = 0.00612$: σ =		15,400 psi
Critical Load, $P_{cr} = A\ \sigma$	68,680 lb	61,600 lb
$\sigma_{working}$ by AISC Formula	12,150 psi	12,150 psi
Working Load by AISC Formula	48,600 lb	48,600 lb
P_{cr}/Working Load by AISC Formula (= Safety Factor of AISC Formula)	1.413	1.267

3. The Critical Load of a Cylinder and Piston-Rod Assembly

The critical load is to be determined for a cylinder and piston-rod assembly from the following design data:

Maximum length, pin to pin, L	55.0 in.
Piston rod, solid; diameter	1.75 in.
Cylinder; outside diameter	7.0 in.
inside diameter	5.75 in.
Length from piston-rod bearing to inside of gland at cylinder, b_1	26.5 in.
Initial eccentricity: 0.30 percent of L	0.165 in.
Yield point of both pieces (steel)	36,000 psi

The relative stiffness of piston rod and cylinder is to be determined first:

	Piston Rod	Cylinder
I, outside	0.4604 in.^{4}	117.79 in.^{4}
I, inside		53.66 in.^{4}
I, net	$I_1 =$ 0.4604 in.^{4}	$I_2 =$ 64.13 in.^{4}
Relative stiffness, I_1/I_2	0.00718	

The ratio b_1/L is $26.5/55.0 = 0.482$. Fig. 9 shows that for $I_1/I_2 = 0.007$ and $b_1/L = 0.482$, the equivalent length of bar with stiffness I_1 is $l_1 = 0.78L$. (In this figure the notation $I_1/I_2 = 1.00$ applies to the top straight line of the chart.) The equivalent length is thus $l_1 = 0.78 \times 55.0 = 42.9$ in. The length of the piston rod is greater than half the length of the equivalent bar (see p 119, PRODUCT ENGINEERING, Oct. 1949); the greatest initial eccentricity of the assembly should thus be assumed to occur in the piston rod. According to the assumption of sine curves as deflection lines for piston rod and cylinder, the maximum initial deflection should occur at $l_1/2 \approx 21.5$ in. from the piston-rod bearing, and this is the position where the piston rod is most likely to fail first. The cylinder is obviously so much stronger than the piston rod that only the piston rod need be checked. The calculation now proceeds as in the previous examples:

l_1	42.9 in.	e	0.165 in.
$r = d/4 = 1.75/4$	0.4375 in.	$n = e/l_1$	0.00385
l/r	98.1	z = (from Table I)	0.5000
n/z			0.00770
From Fig. 4, $n/z = 0.006$, $\sigma_{tot} = 36{,}000$, find σ			16,100 psi
From Fig. 5, $n/z = 0.008$, $\sigma_{tot} = 36{,}000$, find σ			14,400 psi
Interpolate for $n/z = 0.00770$; σ			14,650 psi

The area of the piston rod is 2.405 in.^{2} The critical load is thus calculated as $2.405 \times 14{,}650 = 35{,}230$ lb.

This cylinder and piston-rod assembly was actually tested to destruction. The initial eccentricity was determined by electrical strain gages as being 0.168 in. Several piston rods of the group were tested for yield point stress and the range found was from 35,000 psi to 44,000 psi. The assembly buckled at a load of 39,500 lb, and the maximum curvature of the piston rod was observed at 20.5 in. from the piston-rod bearing.

The test results agree quite well with the calculation. The point of maximum curvature was calculated accurately, and the deviation between the actual and the calculated critical load is within the range of the observed yield point stresses.

It should be noted that the method of calculation is somewhat conservative, because a column does not fail immediately when the yield point is reached at the extreme fiber, as can be proved by a more elaborate analysis. For most practical problems this is not warranted.

Germans Highly Successful In Welding Plastics

GERMAN WARTIME WELDING of thermo-plastic materials may have important peacetime industrial applications, according to a report issued by the Office of Technical Services.

Three main welding techniques are reported to have been used by the Germans: Gas welding of polyvinyl chloride and polyisobutylene; heated tool welding of polyvinyl chloride; (including seam welding of the Pfaff Welding Machine); and friction welding of polyvinyl chloride.

The body of the report, prepared by British investigators, consists of complete descriptions of observations made at 21 leading German plants. Illustrations show plastic welded articles ranging from raincoats to ventilating ducts. Additional sections deal with literature, trade names and instruction for welding of Plexiglas.

Success of the Germans was due largely to the interest of manufacturers who developed weldable materials, and the limitation of raw materials to firms familiar with the field. A measure of the importance of the new techniques is indicated by the fact that 2,000 men were trained as specialists in plastics welding during the war.

Report PB 97852, *Welding Plastics in Germany*, contains 128 pages including photographs, drawings and tables, sells for $16.25 in photostat form, $5 in microfilm. Orders should be addressed to the Library of Congress, Photoduplication Service, Publication Board Project, Washington 25, D. C., accompanied by remittance payable to Librarian of Congress.

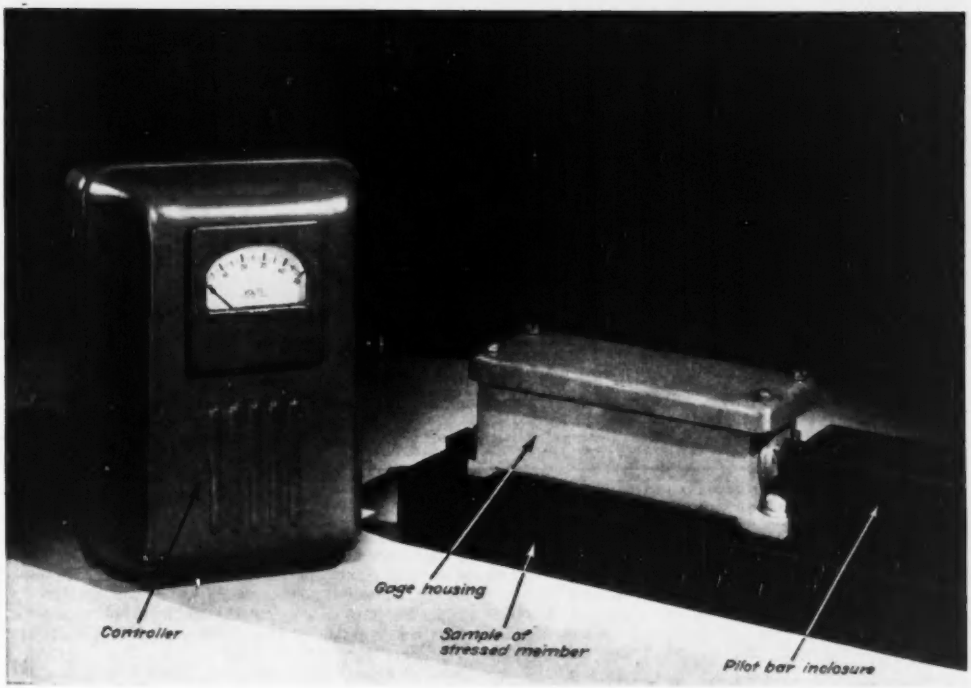

Fig. 1—Gage housing contains two reactors between which magnetic armature floats. Pilot bar under inclosure is clamped at outboard end in a pedestal welded to test section. Bar can be cut to any desired length up to a maximum of 24 inches.

A Magnetic Strain Gage For Static Metallic Members

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Westinghouse Electric Corporation

MAGNETIC STRAIN GAGES provide a simple, low cost medium for measuring small distortions in static structural members subjected to tensile or compressive loading. This stress problem is important in applications such as crane booms where varying loads are encountered and safe loading limits are not to be exceeded.

Instrumentation shown in Fig. 1 consists of the gage proper, a 24 in. pilot bar with mounting and a small controller. The cast iron gage housing is watertight and suitable for direct mounting on the stressed member, while the controller has a general purpose enclosure for remote mounting. Load is indicated by the meter and overload warning can be provided by lights or audible signals.

Two variable reactors, X-1 and X-2, and a common armature make up the gage shown schematically in Fig. 2. The reactors are connected in series to the controller that consists of a matching potentiometer, a high impedance voltmeter and a relay. These elements form a bridge circuit that requires only a single phase, 110 v, 60 cycle power supply of 35 v-a capacity.

The gage is rigidly mounted on the member so that the air gaps of the reactors are approximately equal at no load. The bridge is then balanced by adjusting the potentiometer. Strain in the member will cause movement of the armature thus increasing the impedance of one reactor and decreasing the impedance of the other. This un-

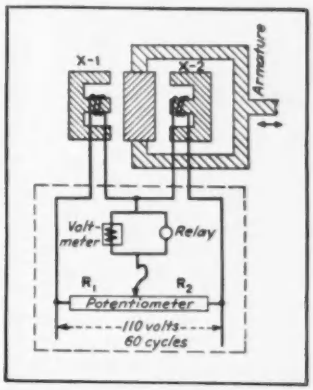

Fig. 2—Schematic diagram of gage controller bridge circuit and variable reactors.

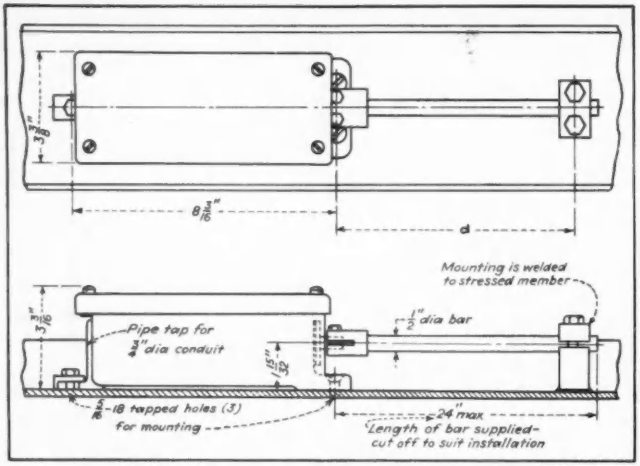
Mounting is welded to stressed member
Pipe tap for ¾" dia conduit
1" dia bar
¼-18 tapped holes (3) for mounting
24" max
Length of bar supplied- cut off to suit installation

Fig. 3—Gage assembly and pilot bar are attached at three points. After bar is cut to calculated length, outboard mounting is aligned with shims and welded in place.

balance results in a differential voltage that is indicated on the meter.

Output voltage is linear with respect to armature travel over the usable range of the gage. Since the maximum displacement for this range is 0.003 in. of armature travel, the gage should be applied so that maximum distortion to be indicated is resolved within this limit.

Assume a steel member is in tension and the maximum allowable stress to be applied is known. Taking Young's Modulus for steel as 30 x 10^6 and the maximum gage displacement of 0.003 in., the length *d* of the pilot bar shown in Fig. 3 will be 90,000 divided by the maximum allowable stress.

The pilot bar mounting is therefore welded to the steel section at distance *d* from the center line of the gage-front mounting bolts. One end of the bar is attached to the gage armature and the other end is clamped to the mounting. Full stress on the section will then produce a 0.003-in. displacement of the gage armature.

In all applications, the gage mounting should be rigid, as any amount of backlash will produce an oscillation or chatter in the armature. These disturbances induce voltages across the bridge and result in incorrect meter readings.

Temperature compensation is obtained by using a pilot bar of the same material as the test section. Ambients can be further equalized by placing a "U" shaped enclosure over the bar with the open side next to the member.

This type of strain gage, which is accurate to approximately ±7.5 percent, should not be mounted on steel or other metallic members that are stressed below 3,600 pounds per square inch.

Rare Earth Metals in "Mass" Production

ATOMIC RESEARCH has made possible the identification and separation of many chemical elements that, up until World War II, were known only to exist. Most of these new-comers are the rare-earth metals that fill the gap from 57 to 71 in the periodic table.

Once rarer than diamonds and actually priceless, these elements are now being produced in pound lots by a method born of the atomic-bomb project.

Early in 1944, scientists on this project made the amazing discovery that rare earths formed by uranium fission could be separated—in hours instead of years—simply by passing a solution of them through a vertical tube filled with synthetic resin. Samples were, at first, sub-visible "tracer" quantities; later, visible ones of ten-thousandths of an ounce.

Subsequently, two young chemists in the Clinton Laboratories at Oak Ridge separated a mysterious substance from fission-produced neodymium with one of the new resin tubes or "ion-exchange columns." It proved to be the missing rare-earth element No. 61, which they named prometheum.

Under the guidance of Dr. F. N. Spedding, Iowa State chemist, the Atomic Energy Commission has since set up "mass production" apparatus at the Ames Laboratory. This equipment takes the form of 24 resin columns, eight feet tall and approximately four inches in diameter.

Separation Process

After acid extraction from the ore and preliminary chemical separation into light and heavy groups, the metal-bearing material is redissolved in acid and poured into a resin-filled tube. The rare-earth ions stick to the resin at the upper end of the tube, leaving the acid, which is then removed by washing.

Next, a dilute solution of citric acid and ammonium citrate is poured down the column. These reagents carry the ions down the tube until they again stick to the resin. This slip-stop process repeats itself until all the particles reach the lower end of the tube where bottles collect the droplets.

Particles of highest atomic number reach the bottom first, those of next highest number next, and so on. By switching the liquid output from the tube into one bottle and then into another at the proper time intervals, scientists collect each purified element in a separate bottle. The pouring process is repeated if extreme purity is desired.

Final step in the separation process entails precipitation of rare-earth oxalates from oxalic acid, followed by heat treatment for conversion to rare-earth oxides. Purity of these powders, which are suitable for experimental use, is more than 99 percent.

By "smelting" these oxides, miniature ingots of the pure metals are produced—tiny 1/20-oz cylinders of silvery praseodymium and neodymium metals, sealed against corroding air in helium-filled glass vials, and comparatively massive 1.3-lb chunks of cerium and lanthanum. Their weight compares with iron, their softness with calcium; like the latter, they react with water, liberating hydrogen. Production of one avoirdupois ounce of praseodymium costs almost $1,000; of neodymium, $170; of lanthanum and cerium, $57 each—compared with the $31.90 value of an ounce of pure gold.

Mechanical Computing Mechanisms—IV

- How to develop a mechanical analog computer from a mathematical relationship to a complete schematic design.
- Design considerations, such as limit stops, electrical components and vibration and acceleration effects.

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THE FIRST ARTICLE of this series (PRODUCT ENGINEERING, Aug. 1949, p 131) on analog computers described the initial design procedure. Second and third articles analyzed examples of individual mechanical components to perform the operations of algebra and calculus. The procedure when combining several components into a workable computer now will be demonstrated by analyzing a simple equation such as the well-known Pythagorean theorem, and the principles employed can be extended to more complicated relations involving more variables.

First step is to set up the problem in a mathematical sense and secondly in a mechanical design sense. If a and b are the sides of a right triangle of which c is the hypotenuse, the Pythagorean relation states that $a^2 + b^2 = c^2$. Assume that lengths b and c are to be the inputs to the computer, and the continuous value of the length of side a is the answer required. By modifying the above relation to solve for a,

$$a = \sqrt{c^2 - b^2} \qquad (1)$$

This will serve as a statement of the problem in mathematical terms, at least in a preliminary sense. For the mechanical statement of the problem some facts about the mechanical nature of the input and output analogs must be established.

Assume that two elements sensitive to length are available, from which shaft rotations of linear proportionality to the input quantities b and c are obtained, at a high power level. Suppose the unit of length being measured is miles and length of side b, expected to vary from 1 to 4 miles, may be measured to an accuracy of ± 0.01 miles. The hypotenuse c will range in value from 5 miles to 20 miles, with the same accuracy of measurement. By substituting appropriate maximum and minimum values in Eq 1, the lower limit of side a as 3 miles and the upper limit as 19.98 miles are determined. Thus the ranges of input and output variables are determined.

Before investigating the output accuracy required of the computer, possible accuracy obtainable from these input analogs should be checked as this is often a limiting factor in design.

A very good error analysis may be made quickly if, in general, $a = f(c, b)$ then

$$da = \left(\frac{\delta f}{\delta c}\right) dc + \left(\frac{\delta f}{\delta b}\right) db .$$

Applied to Eq (1), this becomes

$$da = \frac{2c\,dc}{2\sqrt{c^2 - b^2}} - \frac{2b\,db}{2\sqrt{c^2 - b^2}}$$

$$= \frac{c\,dc - b\,db}{\sqrt{c^2 - b^2}}$$

This equation expresses the total error in a due to errors in b and c at a given condition. Maximum errors will result from a minimum value of the radical, implying minimum c and maximum b, in combination with errors of opposite sense.

The problem assumption was

$$|db| = |dc| = 0.01 \text{ miles.}$$

To determine maximum error in a, substitute $c = 5.00$ and $b = 4.00$ miles respectively, while $dc = 0.01$ and $db = 0.01$ miles respectively in the error equation. The maximum value of da is approximately 0.03 miles, and occurs when a is at its minimum value of 3 miles. A good average for all values appears to be about 0.015 miles. It is apparent that errors of this order will occur in the output values, even asuming the actual computer built has no error whatsoever, which is, of course, impossible. If the requirement on output accuracy is 1 percent of full scale reading, it means that an error of 0.20 miles in the length of side a will be accepted. The tolerable maximum error in the computer is, therefore, $0.20 - 0.03 = 0.17$ miles.

Requiring the computer to record the output or control another device would add little of value to this schematic design analysis; so, dial indication of the answer will be assumed.

Many times the size and weight limitations are of paramount importance in selecting components, but detailed analysis of such limitations depends upon the individual project. Suffice it to presume that the finished computer will be of desk-computer size and easily portable.

Now, having arrived at some conclusions concerning the overall picture, the statement of the practical problem is as follows: two shafts are rotating according to the values of b and c respectively. A third shaft is required, whose motion represents a, coupled to shafts b and c by suitable devices so that the relation, $a = \sqrt{c^2 - b^2}$, is everywhere maintained. These three shafts, and the mechanical components which relate their motions, comprise the proposed computer.

To attack the problem from several angles, first re-examine the mathematical statement, Eq (1), and sketch out several block-diagram methods of solution.

This relation may be rewritten as

$$a = b\sqrt{c^2/b - 1} \qquad (2)$$

or as

$$a = \sqrt{(c - b)(c + b)} \qquad (3)$$

Block-diagram solutions of these three expressions are shown in Fig. 17. At first glance there appears to be little choice among the three methods, since in each, four operational blocks are required to perform the solution. However, as was demonstrated in Parts II and III describing computer components, not all the blocks represent the same number of parts or present the same degree of difficulty. For example, the problem of division is quite difficult, and should be

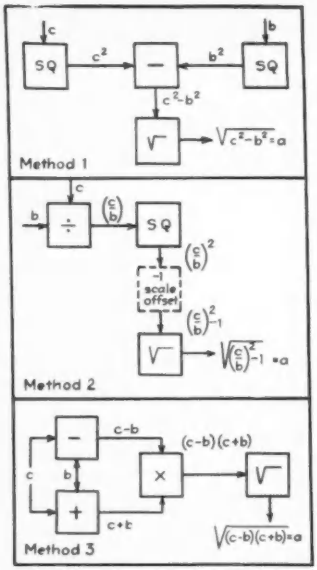

Fig. 17—Block diagram investigation of the different ways of arranging the equation. Method 2 should be discarded because it calls for division. Method 3 is more complex than Method 1, and it is therefore less desirable.

avoided whenever possible; a simple function-generation process such as squaring would certainly be preferred over division; similarly, addition would be preferred over multiplication. Considering the block diagrams on this basis, Method 2 should be discarded first, since it requires both a divider and a multiplier. In choosing between Methods 1 and 3 it can be seen that Method 3 requires a multiplier, which is generally a more complex mechanism than the mechanisms required by Method 1. Therefore, in this particular example nothing is gained by this venture in rewriting the given equation. (Frequently, however, rewriting is definitely justified.) So the original Method 1 can be chosen on the basis of the block-diagram analysis.

Two squaring devices must now be selected, an adder and a square root mechanism, from among the mechanical analog components. A mechanism to obtain the square of an input variable might consist of an integrator in which both inputs are the same quantity and the output is

$$\frac{1}{K}\int b\,db = \frac{1}{K}\,\frac{b^2}{2} = \frac{b^2}{2K}$$

and similarly $c^2/2K$, from a second integrator. The outputs of the two integrators are then subtracted in a rotary differential to produce a difference $(c^2 - b^2)$, which appears as a shaft rotation. A plate cam on this output shaft, rotating as $(c^2 - b^2)$, may be constructed so the follower motion is $\sqrt{c^2 - b^2} = a$, and a gear train designed so that a is converted from linear to rotary motion, and appears on an output dial. Fig. 18 shows the schematic design of this computer.

Mechanizing the block diagram of Method 1 from another approach, the squaring device is considered to be a function generator to mechanize the relation

$$y = f(x) = x^2 .$$

Here $y_1 = c^2$ and $y_2 = b^2$

Since the shaft rotations are proportional to the quantities c and b already available, two rotary plate cams with roller followers provide the squaring devices shown in Fig. 19. The motions of c^2 and b^2 are converted by these devices into translatory motions of two followers, which suggests a simple link differential connecting the two followers. From this the difference, $(c^2 - b^2)$, is obtained. A function generator is required to extract the square root of the quantity now represented by a translatory motion. A cam is chosen to perform this operation, and a rack and gear train to convert the answer to rotary motion of a dial.

Having sketched each proposed mechanization in the form of a schematic design, Figs. 18 and 19, the next step toward achieving a practical design is the investigation of scale factor of each of the proposed mechanisms.

In Fig. 18 the two integrators and the rotary differential are unbounded components; this means that, since they are capable of rotary motions, any amount of rotation may be assigned as equal to one unit of the variable. The square-root cam is not unbounded however. Design practice usually limits the working range of input rotation to something under 360 deg. Therefore, it is necessary to begin with this square-root cam and work forward and back.

To arrive at a reasonable size cam, the total cam throw, and, consequently, the follower travel, should be arbitrarily limited to approximately $\frac{3}{4}$ in. The range of variable a represented by the follower travel has been established as 19.98 miles − 3.00 miles = 16.98 miles. Choosing round numbers for ease in computation the scale factor of the a follower is set as $\frac{3}{4}$ in./15 mile which results in an exact total follower motion of 16.98 miles (1.0 in./20 miles) = 0.849 inches.

The cam-rotation scale factor is similarly determined. The range of $(c^2 - b^2)$ is 399.0 − 9.0 = 390 miles^2, and, although ordinarily plate cam rotations are limited to less than 360 deg, the rotary constrained follower shown permits somewhat more rotation, at the sacrifice of a return path for possible overtravel. If suitable stops are provided, the rotational cam scale factor may be set as

$$\frac{390\text{ deg}}{390\text{ mi}^2} = \frac{1\text{ deg}}{\text{mi}^2}$$

The differential spider scale factor is the same, since the cam is fastened to the spider shaft. Recalling the characteristics of a bevel gear differential, the input gear scale factors are 2(1 deg/mi^2) = 2 deg/mi^2, and this in turn becomes the output scale factor for the two integrators.

The next step is to assume some reasonable sizes for the integrators. Consider a small integrator having a disk with 2.0 in. working diameter and using 1/4 in. diameter balls and roller. The essential characteristic of an integrator used as a squaring mechanism is the proportionality factor K relating the units of disk rotation to the units of carriage motion, conveniently expressed in in./deg. Assuming the b high power level shaft, having a total rotation of 300 deg corresponding to a variation from 1 to 4 miles, is direct-connected to the integrator disk shaft, the disk scale factor is 300 deg/3 mile = 100 deg/mile. The available working radius of the disk is 1 in., to represent a value of 4 miles, or a scale factor of $\frac{1}{4}$ in./mile. The proportionality factor between these scale factors is

$$K = \frac{1/4\text{ in./mile}}{100\text{ deg/mile}} = 0.0025\text{ in./deg.}$$

The mathematical derivation of the integrator law, PRODUCT ENGINEERING, October 1949, p 128, where

x = disk rotation
y = carriage displacement = Kx
w = roller rotation
r = roller radius

yields

$$w = \frac{K}{r}\int x\,dx = \frac{K}{r}\left(\frac{x^2}{2}\right) = \frac{Kx^2}{2r}$$

The last expression relates the input and output rotations. Substituting the input values corresponding to one mile, the output rotational scale factor is obtained where K = 0.0025 in./deg, x = 100 deg and r = 0.125 inches.

$$w = \frac{0.0025\ (100)^2}{2\ (0.125)} = 100\text{ deg/mile}^2$$

The required scale factor was 2 deg/mile² for the differential. Therefore, a 50:1 gear reduction must be provided between the output of the integrator and the input to the differential to match the scale factors. The c input, although having the same rotation of 300 deg, represents a variation of 20 — 5 or 15 miles, a scale factor of 300 deg/15 mile = 20 deg/mile. Substituting this value in the expression for the output of the second integrator,

$$\alpha = \frac{0.0025\ (20)^2}{2\ (0.125)} = 4 \text{ deg/mile}^2,$$

and a 2:1 reduction is needed to match the required differential input of 2 deg/mile².

All scale factors and essential dimensions from the input shafts to the square root cam shaft have been established. Next, consider the scale factors from the square-root cam to the output dial. If the cam is so designed that the angular rotation of the follower arm is linearly proportional to a, a total rise of 3/4 in. will result in an angular displacement of 2 [arc sin $(1/2 \times 3/4)/L$] = 2α where L is the length of the follower arm. If α is chosen as 7 1/2 deg, then a value of L = 2.875 in. is required to produce a total angle of 2α = 15 deg, corresponding to 15 miles, and a scale factor of 1 deg/mile. A gear ratio of 20:1 between the follower arm and an output dial will then result in a dial scale factor of 20 deg/mile, and a total rotation of almost 340 deg for variation in a between limits of 3.0 and 19.98 miles.

At this point essential dimensions and scale factors for the entire computer have been established. Though there are no Class B (theoretical) errors in the solution, this design has approximately 75 major parts, including two integrator lead-screws, approximately 9 pairs of spur gears, and a bevel-gear differential, all of which will tend to cause excessive Class A (mechanical) errors. Further analysis might eliminate some of the spur gears, but a tentative conclusion can be made that another mechanization containing fewer parts should be attempted.

The arrangement of Fig. 19 has input scale factors of 100 deg/mile for b and 20 deg/mile for c, as previously stated. Again each input rotates a total of 300 deg to represent the total change in variable. Assume a 1.0 in. cam throw, for the variable c, that is, a scale factor of

$$1.0 \text{ in.}/(400 \text{ mile}^2 - 25 \text{ mile}^2) = 1 \text{ in.}/375 \text{ mile}^2.$$

If the output is located at the center of the differential link, the output scale factor must be equal to 1/2 in./375 mile² and the scale factor of b must be identical with that of c. This results in a total throw of the b cam of (16 mile² — 1 mile²) (1 in./375 mile²) = 0.040 in. The total maximum motion of slide A is calculated as 399 — 9 = 390 mile² = 0.52 in. For approximately 300 deg rotation of the square-root cam, the pitch diameter of gear B is approximately

$$D = 360\ (0.52)/300 = 0.1985 \text{ in.}$$

Assuming an 80 diametral pitch pinion, the nearest even number of teeth is 16, with a pitch diameter of 0.200 in., therefore, 298 deg/390 mile² = 1 deg/1.31 mile² is the rotational scale factor of the pinion. Assume again a dial rotation of 340 deg = 17 miles, and a scale factor of 20 deg/mile on the output dial. For simplicity in fabrication assume the same pinion is used on the output of slide A; therefore the throw of the square root cam must be 0.2(340)/360 = 0.593 in.

All scale factors and essential dimensions are now assigned to both mechanizations. The second method, the cam solution, again has no Class B (theoretical) errors. The primary objection to the other method was the large number of parts, with inherent Class A (mechanical) errors, and the possibility of slippage in the integrators. The cam solution looks very promising on this basis, having only 10 major parts and workable scale-factors throughout. Final schematic design is shown in Fig. 20, with scale factors.

When drafting the final layout, certain design features must be considered. To facilitate calibrating the assembled components, and to replace

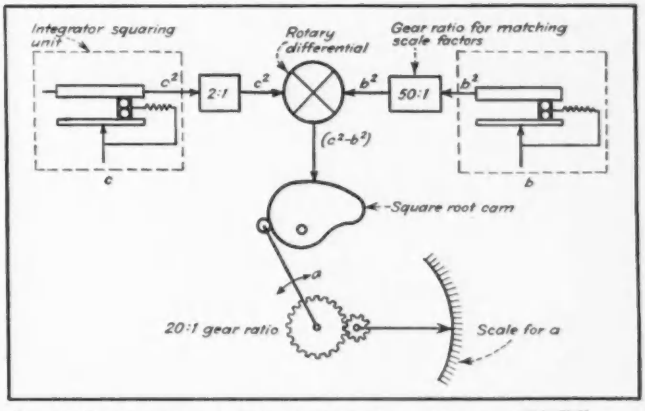

Fig. 18—The integrator method of mechanizing the equation $a = \sqrt{c^2 - b^2}$, shown in schematic form. It requires an excessive number of parts.

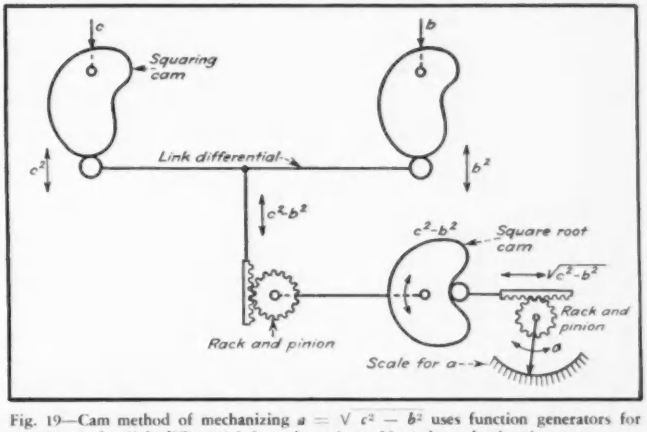

Fig. 19—Cam method of mechanizing $a = \sqrt{c^2 - b^2}$ uses function generators for squaring and a link differential for subtraction. Note the reduction in parts.

components that malfunction, the "unit assembly" method has proved very successful. This allows the unit components to be calibrated when divorced from the computer.

To prevent damage to the computer, stops should be designed to prevent any motion within the computer from exceeding its designed range. The stop should be so located that it will act upon the element that causes the excessive motion, and not on some linkage or other part of the computer. In many applications the stops must be adjustable; then a device for locking is required. Mechanical stops for manual inputs must be of rugged construction, for it is apparent that large torques may be introduced by unskilled operators.

Normally, the pressure and temperature range in which the computer must operate will be given in the specifications, or may be determined by the designer. Extreme temperature changes may cause serious troubles in computers. Close fits will tend to "freeze", and viscous drag fluids will change viscosity. One method of overcoming the difficulties caused by changes in ambient conditions is to have the computer hermetically or gasket sealed and heated internally to maintain constant temperature. This may be accomplished by means of a heater element and thermostat. Many specifications contain a "warm up" clause that requires the computer to be at operating temperature in a specified length of time. In this event, a heating system must be incorporated that will bring the computer to operating temperature in the time specified when exposed to the lowest specified ambient temperature.

The computer should be enclosed in a durable dust proof cover, to prevent damage due to mishandling, and to keep the instrument free of dust. Most computers will be subjected to vibrations and shocks during operation. Thought should be given to the method of mounting, and the type of shock absorber required. There are many anti-vibration mounts on the market, and normally they can be incorporated into the mounting rig.

When the computer contains a sensitive element that measures accelerations, or some gyroscopic instruments, an anti-vibration mounting will introduce errors due to false accelerations, or a time-lag in the response of the element. These errors may be minimized by the use of relatively stiff shock mounts, which will transmit the actual forces and motions in normal operation, but will deflect under shock loads.

It is advantageous to have all rotating parts dynamically balanced, and thereby minimize the acceleration torques. If a "force balance type" servo is used, the force arm must be perfectly balanced for the same reason.

Even though a computer is of the mechanical type, invariably it will contain some electrical parts, such as switches, motors, solenoids, lights and relays. As the design grows, the wiring diagram should be drawn. The electrical components should be added to the layout with the idea of placing them so the wiring will be accessible enough to facilitate disassembly of electrical components. Connector strips provide an excellent aid in wiring.

Some method must be provided for detaching the cable or cables from the computer. The connector allowing this usually is of the pin-socket type. As a safety precaution the part containing the sockets should always be attached permanently to the wires supplying the power. Then, in event the connector is open with the power on, there will be less possibility for a short circuit. If the computer has more than one connector, the connectors should be so selected that there can be no possibility of joining the wrong ones.

The simple analysis given here and the basic mechanisms described in three previous articles, can be applied with equal success to a wide range of computers, including virtually all problems in which the relations among the variable quantities is expressible in equation or tabular form.

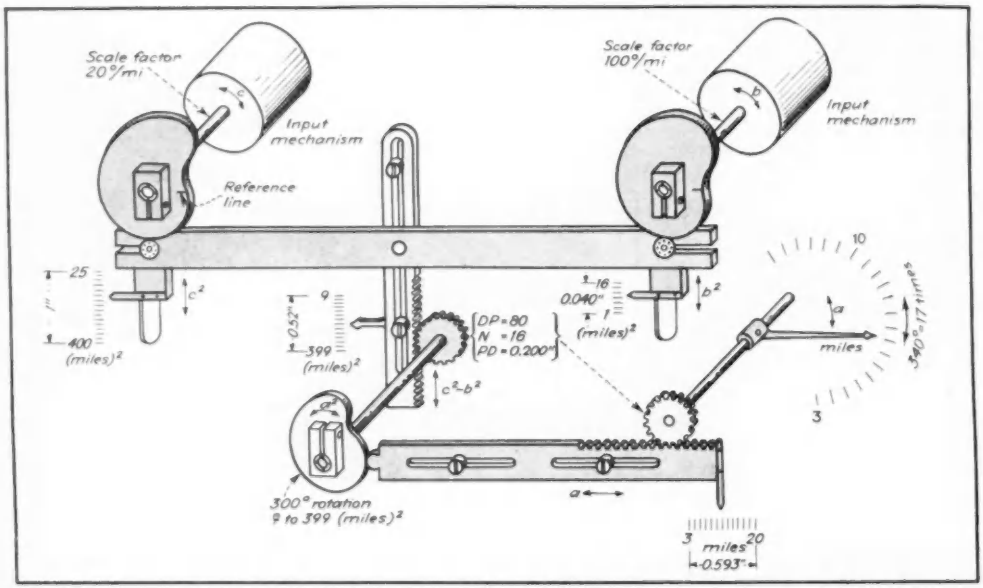

Fig. 20—Final schematic design of the proposed computer is shown, with scale factors. This design, based on the cam method, was selected because far fewer parts (and potential mechanical errors) are included. The value of careful analysis is demonstrated.

ENGINEERING ABSTRACTS

FOREIGN AND DOMESTIC ARTICLES

Forgings of High Strength Aluminum Alloy

From "Design for Forging", *Metallurgia*, (London) February 1949, p 191-194.

THE HIGHEST MECHANICAL PROPERTIES of known aluminum base forging alloys are obtained in D.T.D. 683. Two representative specifications, R.R. 77 and Hiduminium 66 have compositions as follows:

Percent Composition of Hiduminium

Cu	4.1–4.5
Ni	0.15 max
Mg	0.4–0.6
Si	0.75–1.0
Fe	0.6 max.
Mn	0.65–0.85
Al	bal

Percent Composition of R.R. 77

Cu	0.25–0.55
Ni	0.1 max.
Mg	2.6–3.0
Fe	0.45 max.
Si	0.45 max.
Mn	0.4–0.8
Zn	5.3–5.8
Al	bal

Hiduminium is given a normal heat-treatment as follows: Solution treat for 4 hr at 510 C, quench into water at 70 C and age-harden for 7 hr at 185 C. Forgings given this treatment develop minimum properties of ultimate tensile strength of 29 tons per sq in.; yield point, 25 tons per sq in.; elongation, 6 percent.

Aluminum alloy forgings produced of R.R. 77 are heat-treated as follows: Solution treat for 4 hr at 460 C, quench into water at 70 C, age for 15 hr at 135 C. These develop minimum longitudinal mechanical properties of uts, 31 tons per sq in.; yield point, 27 tons per sq in.; elongation, 8 percent.

This paper then covers the forging process and its influence on mechanical properties when applied to cast or extruded materials. Design considerations for forgings of this material are discussed. Close cooperation with the manufacturer and the designer is urged for the production of any particular component. The inherent difficulties in the forming of contours on stampings and their location at undesirable positions in relation to the die parting line can thus be minimized. For maximum life in stamping dies, where tolerances have to be maintained and the component produced on an economical basis, all fillet radii and sections in the stamping that necessitate large vertical or horizontal movement must be kept under careful consideration. For both these alloys, deformation by upsetting will proceed satisfactorily at the forging temperature. But difficulties arise in the running of webs and small bosses when these are removed from the plane of upsetting either horizontally or vertically. Valuable savings in cost due to either ease of production of dies or the working life of the dies can be made by close cooperation between the metallurgist and the designer.

Design must be such that metal is distributed so that no surface plane is worked at the expense of underlying layers and that no point exists where horizontal and vertical stresses are having a simultaneous effect upon the material. Correct lubrication of dies is of the utmost importance. The component design must be closely related to the hammer weight, so that the power available for deformation is sufficient to readily move the metal at the forging temperature without unduly stressing the stamping die surfaces.

The paper then discusses the test bar system of controlling the composition of metal and its response to heat-treatment.

The advent of the gas turbine engine has necessitated the production of components by the forging process to dimensional tolerances previously considered to be impracticable. For these components, Hiduminium R.R. 57 with its high mechanical properties at elevated temperatures and its resistance to intercrystalline corrosion was developed. This material has a composition falling in the range:

Cu	5.7–6.3 percent
Si	0.2 percent max.
Fe	0.3 percent max.
Mn	0.2–0.3 percent
Ti	0.1–0.15 percent

It is solution treated at 530 C, quenched in water, and age-hardened at 215 C; it will develop minimum mechanical properties of uts, 25 tons per sq in.; proof stress at 1 percent, 14.5 tons per sq in.; elongation, 8 percent.

In forging gas turbine blades the ultimate success of the process depends upon synchronizing molding dies and the control of dummy weight so that no excess material is available at points of rapid change in section where small surface laps might otherwise occur. For a perfect section, with no points from which fatigue can develop or eddy currents can be set up in the air stream, surface condition must be of an extremely high order. This surface condition was finally achieved by scrupulous attention to the cleanliness of stamping die surfaces, the application of new lubricants and the individual treatment of each component during processing.

Low Temperature Fatigue Tests on Steel

From "Dauerversuche an Staehlen bei tiefen Temperaturen" by Hempel, Kaiser Wilhelm-Institut fuer Eisenforschung, Duesseldorf. ZWB report No. FB 1704/1, dated December 18, 1942. Headquarters Air Materiel Command Translation No. F-TS-1855-RE, Wright-Patterson Air Force Bases, Dayton, Ohio.

A NUMBER OF STRUCTURAL STEELS of different strengths were tested for their resistance to alternating stress at low temperatures. To accomplish this, the industrial materials listed in Table I were subjected to the following tests at +20 C and −78 C: tensile tests, fatigue tests, notched bar impact tests and hardness tests. The results of these tests are listed in Table I. The fatigue tests were performed on an axial loading type machine, with zero mean stress.

Ever since the endurance limit has been included in the characteristic

Table I—Mechanical Properties of the Materials Used

Type of Steel	Aircraft Structural Steel Designation	Brinell Hardiness Number (5/750/30)			Tensile Strength kg per sq mm		Percent Elongation		2 Percent Yield Point		Notch Impact Strength mkg per sq cm		Endurance Limit Under Axial Loading			
		At Surface	At Center										Smooth bars		Notched bars	
		+20 C	+20 C	−78 C	+20 C	−78 C	+20 C	−78 C	+20 C	−78 C	+20 C	−78 C	+20 C	−78 C	+20 C	−78 C
Cr-Mo-Steel	1452	186	181	200	61.4	73.8	29.6	29.0	49.5	58.8	25.3	17.3	29.0	40.0	14.0	16.0
		....	234	265	80.4	90.7	21.8	19.4	67.0	75.9	22.2	21.3	40.0	43.5	16.0	20.0
		....	278	298	95.5	108.5	18.7	15.7	85.3	99.0	19.0	8.2	49.0	54.0	18.0	20.0
Cr-Ni-Mo-V-Steel	1460	272	268	292	90.2	100.5	21.5	22.6	80.2	86.3	20.8	10.9	44.0	52.0	18.0	20.0
		361	356	376	122.1	132.6	16.3	17.7	108.4	117.9	10.9	5.6	58.0	62.0	22.0	24.0
		372	368	389	122.7	135.5	16.6	17.4	110.0	120.0	6.8	4.1	57.0	61.0	20.0	20.0
		397	396	415	138.8	147.3	13.9	13.7	123.2	133.7	5.8	2.8	60.0	63.0	18.0	18.0
Cr-V-Steel	1604	211	195	215	64.9	75.1	29.5	20.4	41.1	47.9	11.6	0.7	31.5	37.0	12.0	14.0
		246	232	249	76.5	87.9	22.8	25.8	68.0	76.6	21.7	9.5	38.0	41.5	14.0	14.0
		322	300	316	98.2	106.7	18.5	24.1	88.5	96.3	14.4	5.7	48.0	55.0	14.0	14.0
Cr-V-Steel	1610	271	269	298	92.0	106.3	18.7	19.7	79.5	89.4	11.8	4.6	40.0	43.0	11.0	11.0
		280	279	309	92.5	105.4	20.3	20.9	82.5	92.7	11.4	5.5	48.0	51.0	12.0	14.0
		406	399	424	138.1	151.3	10.9	10.1	129.2	140.2	4.6	3.5	56.0	57.0	16.0	16.0
Cr-V-Steel	1620	....	287	311	95.4	106.1	20.1	21.3	84.5	91.5	17.3	7.0	47.5	53.0	18.0	22.0
		337	355	380	121.2	132.1	16.4	16.7	110.1	119.4	5.7	4.2	59.0	62.0	20.0	22.0
		352	370	392	122.7	133.1	16.2	17.0	110.9	120.6	4.6	1.8	59.0	62.0	20.0	22.0
		393	398	413	135.6	147.8	13.5	13.7	127.1	140.1	6.9	5.2	60.0	63.0	14.0	14.0
St. C 45.61	1130	244	236	260	79.4	89.8	22.1	24.2	61.9	67.1	14.7	6.1	35.0	44.0	13.0	13.0
		244	240	261	80.8	95.0	23.7	24.7	64.3	74.7	12.6	6.0	38.0	44.0	11.0	11.0
St. C 60.61	1150	276	....	....	95.6	106.9	18.5	19.1	63.8	72.8	5.0	0.8	40.0	50.0	14.0	16.0
EC 80	1207	378	....	....	109.7	120.1	13.2	15.5	82.4	90.4	9.1	5.4	35.0	42.5	16.0	18.0
EC 100	1208	408	....	....	149.4	159.0	12.9	14.5	121.7	133.6	9.0	6.4	60.5	65.5	17.0	17.0
VC 135	1253	285	296	321	98.5	109.9	17.3	19.5	86.6	95.7	9.1	3.0	48.0	53.0	20.0	20.0
		284	291	312	95.6	107.9	17.1	18.0	83.1	92.6	8.8	1.7	44.0	48.0	15.0	15.0
Mn-Steel	1265	239	224	242	74.1	84.3	21.9	24.1	61.1	68.9	19.3	6.8	34.0	41.0	12.0	12.0
Mn-Steel	1267	275	264	287	89.8	101.2	19.5	21.7	78.3	86.9	10.1	2.3	36.0	42.0	14.0	14.0
		308	290	310	97.4	110.3	17.3	18.8	86.6	97.4	10.9	5.1	44.0	47.0	13.0	13.0
Mn-V-Steel	1310	274	304	326	102.9	114.2	15.7	17.2	93.1	98.9	4.9	3.4	45.5	51.0	20.0	20.0
Cr-Mo-Steel Casting	1811	290	273	295	92.1	102.4	13.8	15.3	79.3	87.1	10.2	3.9	30.0	34.0	14.0	14.0

properties for the selection and evaluation of a material, attempts have been made to ascertain the endurance limit from the data obtained in the tensile tests. All experiments proved that the ratio between the different values is never constant and that only a rather approximate relationship exists between the endurance limit and the tensile strength. Table I shows practically the same ratio of endurance limit to tensile strength, approximately 0.455, for the smooth bars of the experimental steels at the test temperatures of +20 C and −78 C. When these ratios are plotted against tensile strength, most points fall within a spread of approximately ±10 percent. Two exceptions with low endurance limits are Aircraft Structural Materials Nos. 1811 and 1207. The first is a chromium-molybdenum steel casting. The second is steel EC 80. It was not properly heat treated.

Computation of the ratio of endurance limit to yield point for smooth bars from Table I shows that this ratio decreases as the yield point increases.

In Table I, the endurance limits of smooth and notched bars have been compiled at the temperatures +20 C and −78 C. From these results, it may be concluded that the notch impact toughness does not influence the endurance limit of smooth bars, as for bars of approximately equal tensile strength but different notch impact toughness, the deviations of the endurance limit are small. The results are, however, not so conclusive regarding the influence of the notch impact toughness on the endurance limit of notched bars. Here an increase of the notch impact toughness is sometimes accompanied by a large increase and sometimes by a large decrease.

Sometimes in low temperature fatigue tests at a comparatively high alternating stress, the cooling liquid does not absorb the heat generated by the alternating stress. As a result, the bar temperature rises and premature fracture takes place. In these cases, the number of cycles at which

failure occurs does not correspond to an experimental temperature of —78 C, but rather to one considerably higher, lying actually between —78 C and +20 C.

The S-N curves for some steels at both temperatures are identical at high stress levels, but for others, they are entirely different at the different temperatures. It was found that smooth bars have a higher endurance limit at —70 C than at +20 C.

The following conclusions were drawn from the test results of Table I:

1. The increase in tensile strength at —78 C over that at room temperature is dependent on the original strength. The increase drops approximately from 18 percent to 8 percent as the strength rises.

2. At +20 C as well as at —78 C, the yield point ratio increases up to a strength of 120 ±5 kg per sq mm. Beyond 130 ±5 kg per sq mm, no further increase takes place compared to that below 120 ±5 kilograms per square millimeter.

3. At +20 C, the ratio of endurance limit to tensile strength decreases with increased tensile strength more rapidly than at —78 degrees Centigrade.

4. The ratio of notched endurance limit to tensile strength is comparatively low and decreases as the tensile strength increases, especially above 120 ±5 kilograms per square millimeter.

In addition, the effect of temperature on endurance life at high stress levels was investigated. No increase in notch sensitivity at high stress levels was observed with a decrease in temperature to —78 C. The author suspects, however, that such effects might be observed when tests with less scatter are made. It was concluded, however, that the notch sensitivity increased as the stress level decreased and as the tensile strength of the material increased.

Importance of Incentive to Invention

Foreign abstract from "Invention and Sifting Out Engineering Facts" by E. G. Bailey. *The Engineer*, (London), April 29, 1949.

MANY PEOPLE SAY upon seeing a new device: "How simple; I could have invented that," and no doubt they could have done had they possessed the necessary incentive. The incentive to improve is of greater importance and yet is seemingly less prevalent than the ability to invent when some specific objective is to be attained.

"Art imitates nature and necessity is the mother of invention," (Ref. 1) was written nearly three hundred years ago, and sixteen hundred years after Persius (Ref. 2) said "Hunger is the teacher of arts and the bestower of invention." Today these phrases, although often used, seldom apply in the same way as they did before the advent of the steam engine and the use of electricity.

Incentives for invention may be generally classified as follows:

(a) The need for new products, processes, or services.

(b) The need to produce a product, perform an operation or process, or render a service, either

(1) With less labor, or

(2) Through the use of less or more readily available material or equipment, or

(3) In less time, or

(4) At less cost.

(c) The challenge to do something new for the gratification of accomplishment.

(d) The desire to benefit mankind.

The great majority of inventions have been motivated by the first two incentives.

Some may question the omission of financial gain as an incentive to invent. It has been purposely omitted as a primary incentive because money alone is very rarely the motivation for a useful invention, although the first two incentives listed above usually lead to some financial gain if successful.

In the United States today most engineering employees freely sign patent agreements whereby any inventions made by them along the line of the employer's activities are assigned to him. Some people think that this tends to stifle the incentive to invent, but observations over a long period of time have shown that there is no withholding of ideas for this reason. Employers usually show their appreciation to employees with creative ability by offering them promotions and assigning them duties resulting in increased prestige and pay. Unfortunately, some employers fail to bring as many engineers into contact with research and new problems as they should for their own best interests.

There may be a lessening of inventions from the journeyman type of worker, partly because today's developments more often than not require advanced engineering knowledge, and to some extent because labor organizations tend to restrict incentive for advancement on merit. On the other hand, the engineering graduate often lacks experience of actual shop work, and has not had the opportunities to see and tackle practical problems directly.

How Inventions Are Made

It is impossible to learn how some of the earlier inventions were made. A few illustrations and a classification of different kinds of invention into groups might, however, be helpful.

Primary Inventions—These are most difficult where there is nothing in nature or in previous knowledge to suggest a solution to a problem.

The wheel and axle, the Arabic number system, with its symbol for zero, and the steam engine, are illustrations of this group. The need for power, although great, was only conceived in terms of men and horses, and later, windmills and water power, until such methods were found to be insufficient for keeping the Cornwall mines drained. Nothing in nature pointed to the combination of fire, boiler, water, steam, pistons, valves and condenser.

Today we have extensive knowledge and many more tools with which to work, and perhaps there remain but few potential inventions within this group.

Secondary Inventions—These are moderately difficult, and include the telegraph, telephone, electric arc and incandescent lights, electric motors, steam turbine, phonograph, cinema, motor car, airplane, television.

This group of inventions requires incentive and inventive ability of a high order, but we now have more background of previous accomplishment, and more tools with which to work. This large and important field of activity should continue to receive our best attention. It includes many potential inventions not now recognized as being needed or of possible achievement, even by those most familiar with a given branch of engineering.

Easiest Inventions or Discoveries—These can be divided into three classes, namely:

(a) Observations of phenomena

which could be usefully applied.

(b) Improvement on prior inventions.

(c) A new use of an existing invention.

General Procedure for Invention—To invent most effectively requires orderly thinking. Probably the best general pattern to follow is to:

(a) Exercise powers of observation, encompassing everything available in nature, engineering and other phenomena, where the functioning of natural laws are involved. Observe unusual phenomena, and try to arrive at an understanding before dismissing them from the mind.

(b) Train the memory to be selective, with respect to observations and information within all fields of interest and possible usefulness.

(c) Analyse, coordinate, classify and associate knowledge acquired within the fields of interest.

Henry Le Chatelier said in regard to selective memory:

"If the mind can be guided never to think of useless things, the power of production would be augmented enormously."

Specific Procedure for Invention—When a particular problem has presented itself it should be concentrated on and studied until a satisfactory solution is attained and the invention completed. The following points indicate a possible procedure:

(a) Study the previous work on the subject sufficiently to acquire aid, but not so much as to become discouraged or distracted from the right answer, which may not yet be in the literature. Too much work in the library may be a waste of time, and probably worse than too little.

(b) Acquire intimate knowledge of the problem and the limitations of existing methods and equipment by working with one's own hands within the field of activity involved.

(c) Give rein to intuitive, imaginative, and even "crazy" thinking. It may help to get out of a rut.

(d) Think without ceasing at any and all hours of the day or night, for suggestions or ideas may flash into the mind at any time. Invention and a forty-hour week are strangers.

(e) Keep mental pictures and drawings in a formative status at all times; review and change them as the work progresses.

(f) Perform the necessary experimental work to prove certain phenomena and relationships, since relatively few inventions can be completed without it.

(g) Work out all possible permutations and combinations of the several factors or increments involved in the device or method. The first design is seldom the best.

(h) Search diligently for the link which is often missing and most difficult to grasp. It may be an important factor or a secondary increment detracting from perfecting the whole. It may be necessary to keep a network of thoughts open for a long time while endeavoring to find the last link to complete the chain.

The making of an invention through study, observation and orderly thinking is not appreciably different from the process followed by the artist, composer, author, business man, or others who have made many worth-while contributions to civilization.

Reduction To Practice

Every worth-while invention should be reduced to practice and thoroughly tested before it is placed into extensive use, in order to:

(a) Make sure that it performs as expected in the hands of critical operators and users, under a variety of conditions.

(b) Obtain criticism and suggestions from others.

(c) Sift out facts and make improvements, if needed, as soon as possible. The pride of authorship should not be permitted to stand in the way of evaluation of the invention on its true merits.

(d) Avoid the inclination to make changes too frequently after the product is placed on the market, even though they may be improvements.

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Machine Tool Hydraulic Systems

Abstracted from "Machine Tool Lubrication on the Production Line", *Lubrication*, May, 1949. Published by The Texas Company.

PROBABLY NOWHERE on a machine tool can trouble occur as often as in the hydraulic system if accepted maintenance procedures are not followed. These include the use of the correct grade of oil with a quality commensurate to demands placed on the oil by the hydraulic system.

Many factors contribute to the need of special care in selecting hydraulic oils. Conditions that cause oils to oxidize present one of the foremost. These conditions include: Operating temperatures ranging up to 150 F; severe agitation at each pass through pumps and valves; pressure; and the presence of metallic catalysts and contaminants such as cutting oils.

With oxidation retarding inhibitors in hydraulic oils, field experience has shown that intervals between drain periods may be increased many times over that obtained with straight mineral oils, and the possibility of gum or sludge formation is greatly reduced.

Rust formation is another factor contributing to poor hydraulic system performance. Rust formation can be prevented by the addition of small amounts of inhibitors to the oil. These inhibitors "plate out" on metal surfaces, forming a film impervious to rusting action of moisture and air.

Foaming can be reduced by treating or processing the oil so that any entrained air in the oil is quickly separated. The presence of air in hydraulic oils can result in erratic motion of actuated parts, and can cause the oil to oxidize more rapidly.

Practically all hydraulic pumps used on machine tools require the use of two grades or viscosities of oil, one being 150 and the other approximately 300 seconds at 100 F Saybolt Universal. It is necessary that the viscosity be sufficiently high to prevent metal to metal contact and to give high volumetric efficiencies, yet it must be low enough to pump easily so that pressure drop through the system is at a minimum.

On close fitting parts, the use of an oil having too high a viscosity has several disadvantages. Internal friction developed in the oil can cause it to overheat, resulting in more rapid oil deterioration and heating up of the metal parts surrounding the oil. The latter is particularly troublesome on machines working to very close tolerances, since the excessive heat generated may be sufficient to expand the frame of the machine or parts thereof to such an extent that the cutting tools or work must be reset periodically.

Effective performance of hydraulic systems in machine tools, of course, is also improved: By the efficient use of filters to keep out contaminants; and by the use of an oil that will function over long periods of time without appreciable change in physical and chemical characteristics.

our next major metal . . . TITANIUM

• Detailed data on a metal that may have an application potential equal to stainless steel and perhaps to some of the non-ferrous alloys.

What Industry and Researchers Think of Titanium

Why Use Titanium?

Availability of the Ore

Production of the Metal

Mechanical Properties of Titanium

Physical and Chemical Properties

Fabrication Techniques

Titanium Alloys

A SPECIAL **PRODUCT ENGINEERING** PROGRESS REPORT

What Industry and Researchers Think of Titanium

The engineering properties of titanium are outstanding. Only the problem of cost stands in the way of its extensive use as a structural material.

—L. W. Eastwood
Columbus, Ohio
Battelle Memorial Institute

I'd say that titanium and titanium alloys will become primary structural materials within the next 5 to 10 years. Its outstanding properties and the availability of rich ore deposits indicate that it can't miss. The cost problem will be licked.

—E. I. Larsen
P. R. Mallory and Co., Inc.
Indianapolis, Ind.

Our metallurgists think that titanium has a big future, but that much more development is needed. Like most other new materials or processes, it will slowly find its proper and economic field of application, depending on price and properties, which are still to be determined.

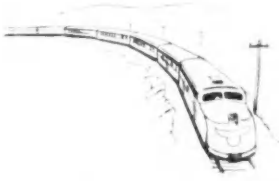
—John Seastone, Mgr.
Materials Engineering Department
Westinghouse Electric Corporation

Titanium may some day fill the gap between aluminum alloys and stainless steel insofar as density and strength at elevated temperatures is concerned. It does not seem optimistic to visualize titanium as a tonnage industry within the next 10 years.

—E. A. Gee
Pigments Division
E. I. duPont deNemours & Co.

In view of the known deposits of titanium bearing ore, it is doubtful that ever again will we have to rely on other countries for supply. The deposits now being developed should last at least 100 years, even under greatly expanded usage.

—Dr. O. C. Ralston
Bureau of Mines
U. S. Dept. of Interior



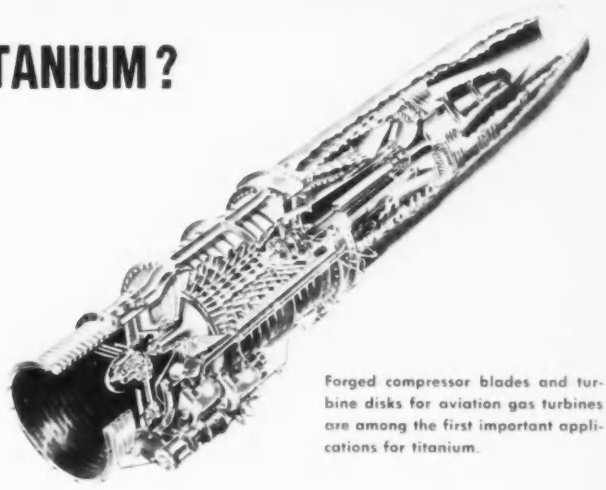
To visualize the potentialities of titanium alloys in ordnance applications, one merely needs remember that in the future, armies and their equipment must be capable of being airborne. With a metal having such promising characteristics as titanium, only its high cost and the lack of information about the properties of its alloys preclude immediate widespread adoption.

—Lawrence S. Foster
Watertown Arsenal Laboratory
Army Ordnance Dept.

At present money and effort are being applied at a greater rate to the development of titanium and titanium alloys than ever before in the development of a structural material. In my opinion, titanium will have progressed five years from now to a degree comparable in significant respects with stainless steel over the past 40 years.

—N. E. Promisel, Materials Branch
Bureau of Aeronautics
Navy Department

WHY USE TITANIUM?



Forged compressor blades and turbine disks for aviation gas turbines are among the first important applications for titanium.

THERE is but little doubt that titanium will be our next major structural material. Its development foreshadows immediate advancements in supersonic aircraft, rocket, and gas turbine design – and foreseeable improvements in thousands of other industrial and consumer products. Those are the opinions of metallurgists and engineers both in government bureaus and in private industry. All see in this metal a possible application potential equal to that of stainless steel and perhaps rivaling that of some of the lighter metals.

There are several good reasons for such optimism. Titanium is plentiful, being the fourth most abundant structural metal in the earth's crust, only aluminum, iron, and magnesium are present in greater percentages, Table I. Its corrosion resistance is as good as platinum and better than that of nickel, stainless steel and the cupro-nickel alloys in sea water and in certain other media. On an equal strength basis, its weight is less than aluminum or stainless steel; some alloys have been developed with a tensile strength of 190,000 psi and a density only slightly greater than pure titanium, or 0.162 lbs per cubic inch. It can be easily welded, forged, and hot worked. In the alloyed state, its electrical resistivity may exceed that of any other material. Its hot hardness, depending on the amount and kind of alloying elements is as great as 32 R_A at 1,100 F. Its oxidization resistance up to 1,400 F, and its creep strength at 1,000 F are excellent. And because of its ability to be surface hardened, it should find considerable use for parts subject to abrasive wear, such as pistons, cylinders, and other engine components.

As with other materials, however, there are certain disadvantages connected with its use. For one, its machinability is poor. For another, certain alloys probably will have to be worked in the hot state, at least to the extent as is 75S-T aluminum, and probably at higher temperatures. And last but not least is its cost – which now makes it exorbitant for other than military use.

Du Pont is quoting prices of $5.00 per lb for titanium sponge and $7.50 per lb for 100 lb ingots. Sheet and bar range from $15 to $20 per lb, depending on the supplier. But new or modified methods of refining ilmenite ore and producing titanium tetrachloride have been developed, with the result that the price of this material has already been cut substantially in the laboratory, and soon will be on a commercial basis. Du Pont is reportedly looking ahead to a price of $1.50 per lb for titanium sponge when their production reaches on the order of 12,000 lb per day. (It now is over 100 lb per day and will soon be increased). Dr. O. C. Ralston, Chief of

Table I – Common Elements in Earth's Crust

No	ELEMENT	ESTIMATED AMOUNT PERCENT	No	ELEMENT	ESTIMATED AMOUNT PERCENT
1	Oxygen	46.59	19	Zirconium	0.026
2	Silicon	27.72	20	Nickel	0.020
3	Aluminum	8.13	21	Strontium	0.019
4	Iron	5.01	22	Vanadium	0.017
5	Calcium	3.63	23	Carium and Uttrium	0.015
6	Sodium	2.85	24	Copper	0.010
7	Potassium	2.60	25	Uranium	0.008
8	Magnesium	2.09	26	Tungsten	0.005
9	**TITANIUM**	**0.63**	27	Lithium	0.004
10	Phosphorus	0.13	28	Zinc	0.004
11	Hydrogen	0.10	29	Columbium and Tantalum	0.003
12	Manganese	0.052	30	Hafnium	0.003
13	Sulphur	0.050	31	Thorium	0.002
14	Barium	0.048	32	Lead	0.002
15	Chlorine	0.037	33	Cobalt	0.001
16	Chromium	0.032	34	Boron	0.001
17	Carbon	0.030	35	Beryllium	0.001
18	Fluorine	0.026			

Lindgren: *Mineral Deposits*. McGraw-Hill Book Company

the metallurgical division of the U. S. Bureau of Mines, has this to say:

"A pound of titanium can be made with a pound of magnesium that costs in the open market $0.21, but in a captive plant, with anhydrous magnesium chloride of high quality all ready to electrolyze, the cost will be somewhat less. Depending on losses of chlorine and magnesium, the power consumption in making titanium will be the 10 kilowatt hours used in making magnesium plus perhaps another 10 kilowatt hours of process and heating power. Skilled labor and amortization on a rather high investment are needed. When all the development work is over and the matter becomes one of operation of a plant making 50 tons or more of titanium per day, it is reasonable to expect a production cost of $0.50 per pound, with a price above that, for titanium ingot."

AVAILABILITY OF THE ORE

THE PRESENT high cost of titanium and titanium alloys is caused by several factors, not the least of which is the difficulty of economically getting it from the ore into the metallic form. As to the other operations, mining is relatively cheap, melting the sponge into ingots presents no particular cost difficulties, and rolling the material into sheet can be done on the same equipment as used for stainless steel.

Titanium is found in ilmenite ore, which consists essentially of iron oxide and titanium oxide. The titanium minerals originate in volcanic rock, but the sands of Florida which received their minerals from degradation of the granite and similar rocks in the Appalachian uplift, are presently the source of much ilmenite ore. The four beaches of Florida where the titanium minerals have concentrated by wave action are due to four periods of uplift of the peninsula, each uplift increasing the area of land surface and leaving older beaches inland.

There the Humphries Gold Mining Company of Denver, operating on contract, are working two properties: One near Jacksonville, where approximately 7,500 tons of sand per day are being processed for the Rutile Mining Company, and another near Fort Blanding, which is the "Trail Ridge" property of duPont. Both are being worked by the same methods – the sand is picked up by suction dredges, pumped to conditioner barges, and finally to concentrating plants. Besides these two developments, there are other older beaches and lakes in Florida that also contain goodly concentrations of ore, but which are not yet being worked.

The National Lead Company has developed the MacIntyre Mine near Sanford Lake at Tahawus, N. Y. There the ore, which averages about 16 percent titanium dioxide (32 percent ilmenite) is mined by open pit methods. Sufficient titanium dioxide was taken from this mine during the war to take care of the major requirements of the pigment industry. About 250,000 tons of ilmenite per year are presently being obtained.

Kennecott Copper and the New Jersey Zinc Company are preparing to start joint operations in far eastern Quebec close to the Bay of St. Lawrence in the Allard Lake region. Fig. 1. Deposits on these properties are estimated to be in excess of 125,000,000 tons of ilmenite containing 32 percent titanium dioxide (65 percent ilmenite). Smaller ore bodies in the same region are estimated to contain from one to several million tons of ilmenite.

In addition to these operations, the American Rutile Company is mining rutile and ilmenite at Roseland, Va.; the Calco Chemical Division of American Cyanamid Company is taking ilmenite and other metal-containing ores from the Piney River region of Virginia; and the Glidden Company, through a subsidiary, is working near the head waters of the Yadkin River.

Other regions in the U. S. where deposits are known to exist are:

(1) In Arkansas, which has fair concentrations

(2) On the coast of Oregon

(3) The central Idaho granite batholite

(4) The Columbia River and delta regions

(5) At the mouth of the Rio Grande, where there is considerable ilmenite and zircon.

Thus, although about 250,000 tons of ilmenite are still being imported per year, the known supplies of the ore here and in Canada are sufficient so that we never again should have to depend on other countries for supply.

Mining ilmenite ore is a relatively inexpensive proposition; suction dredges or power shovels are practical for most deposits. Other factors that lower the cost are the substantial quantities of iron ore taken from ilmenite, and the smaller quantities of other metals such as vanadium.

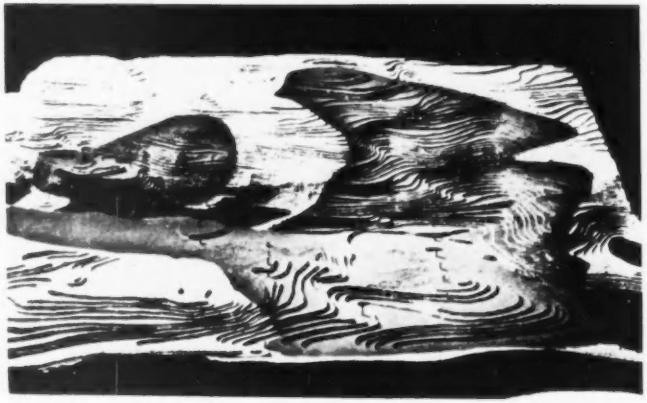


Fig. 1—**An estimated 125,000,000 tons of ilmenite is located in Canada in the Allard Lake region. Dark regions indicate the ore deposits.**

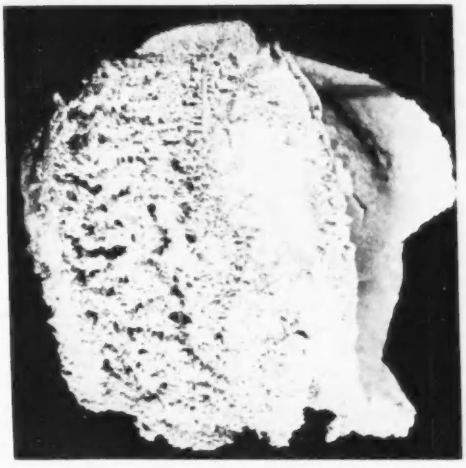


Fig. 2 (Above)—Sponge metal made by reducing titanium tetrachloride with molten magnesium to form "pure" titanium and magnesium tetrachloride.

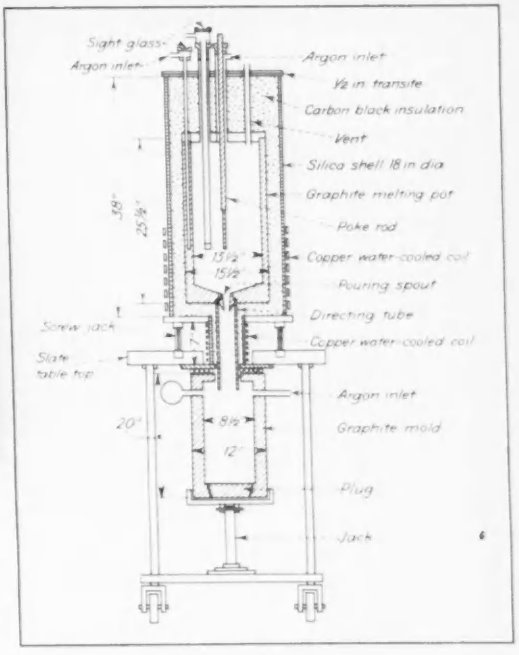


Fig. 3 (Right)—Induction furnace used by duPont to produce titanium ingots. The sponge is melted in a graphite crucible in the presence of an inert gas (argon).

PRODUCTION OF TITANIUM METAL

SEVERAL METHODS or modifications thereof can be used for getting the ore into metallic form. All are batch, and not continuous methods. By treating ilmenite ore with carbon and one of the halogens such as fluorine, chlorine, bromine, or iodine, a tetra compound is produced. Research by two of the potentially largest producers indicates that chlorine will be used to produce titanium tetrachloride. As previously mentioned, substantial progress already has been made toward obtaining cheap titanium tetrachloride. This compound then can be reduced with sodium, calcium, lithium, aluminum, or magnesium.

The Kroll process, which utilizes magnesium and which was developed into a practical method by the Bureau of Mines, is considered by many to be the most promising for large scale operation. The equipment consists of an iron reduction pot or "bomb," which is provided with a tight cover, inlets for the addition of a neutral gas and titanium tetrachloride, and a well for a thermocouple. Pure magnesium is heated in the bomb to about 300 F in the presence of helium, which provides a neutral atmosphere. The temperature is then increased to about 1400 F, and is maintained at that point while the titanium tetrachloride is added. The reduced charge is cooled, a major portion of the resulting magnesium chloride is tapped off in the liquid condition, and the remainder is distilled off under vacuum. The metal then is removed in the form of a sponge, Fig. 2. An alternate method is to tap off most of the melted magnesium chloride, cool the charge, drill out the titanium powder still retaining some magnesium chloride and leach out the latter with acidulated water, and grind the resulting powder after drying.

The Hunter process of reduction is similar to the Kroll method except that sodium is used instead of magnesium. However, magnesium is less volatile so that high pressure and the use of a bomb is avoided.

Another process that some people feel should not yet be counted out of the picture was first suggested by deBoer. It involves the decomposition of titanium iodides on a hot filament. While this method is tedious, expensive, and yields only small amounts of metal per batch, it does produce titanium of relatively high purity.

Getting the titanium sponge into ingots for rolling into sheet or forging into bars also can be done in one of several ways. The sponge can be ground up, pressed into compacts, and sintered in a vacuum furnace for approximately 16 hours at 1750 to 1850 F. Or the sponge can be arc melted in a water-cooled copper furnace in the presence of an inert gas such as helium or argon. Another way the metal can be melted is in a graphite crucible in a controlled atmosphere induction furnace.

Powder Metallurgy

Considerable work already has been done on alloys of titanium made

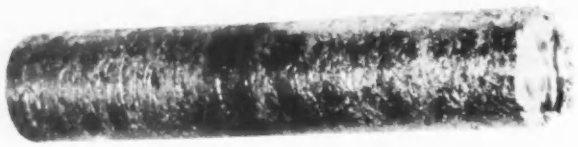


Fig. 4 — **Sixty-pound arc-melted titanium ingot. One hundred-pound ingots are now being melted in arc furnaces, and melting of 400-600 lb ingots is being planned.**

by the powder metal process. But it is extremely doubtful if sintered compacts will be forged or rolled into sheet. While this method of obtaining sheet or bars is practical on a laboratory scale, it is not adaptable for production on a commercial basis.

Sheath Rolling of Powder

A modified method for consolidation of sponge or powder to usable form is that developed by the Bureau of Mines. Titanium powder is placed in a metal sheath and completely sealed in by welding. Then the sheath and powder is rolled directly into sheets. Similar or better results were obtained this way than by using the standard powder metallurgy techniques, followed by homogenization treatments.

The primary advantages of sheath rolling as opposed to conventional powder metallurgy techniques are that (1) it does away with the necessity of compacting the powder under high pressure (50 T); (2) it eliminates the need for vacuum sintering; (3) it permits the preparation of almost unlimited masses of the metal in a single piece; and (4) the metal prepared in this way is dense and smooth, as contrasted to the porous structure usually found in pressed and sintered parts. The sheath-rolled material is similar in structure to conventional sintered material that has been subsequently worked and annealed, and so is ductile and amenable to additional cold working. A number of pressed and unsintered compacts can be made into one piece by this method, and titanium alloys can be prepared by mixing the alloying elements with the titanium powder. Nevertheless, sheath rolling is still a complex operation when compared with the relatively simple one of melting and rolling, so again, the commercial value of the process is doubtful.

Induction Melting

Induction melting of titanium in a graphite crucible is a third method of converting the sponge or powder to usable form. Using this method, titanium is placed in an induction melting furnace, using graphite crucibles, Fig. 3. The melting is done either under vacuum or in the presence of argon gas. DuPont is using this method for all ingots, and has applied it successfully to ingots weighing over 300 lb. And P. R. Mallory has done most of their alloy development with resistance furnaces; they are currently planning on the production of 50 lb ingots in the near future.

Up to the present time, researchers have been unable to find a crucible material which would not react with molten titanium. With all crucible materials to date either the titanium will seep through the pores or become contaminated by reacting with the crucible. In the beginning, the purest grades of graphite were used as crucible materials, but difficulties with flow of the molten metal through pores in the graphite soon led to replacement with denser, less pure forms. National Carbon CS has been used successfully. Even so, there is some carbon contamination, duPont holding their ingots to a maximum of about 0.8 percent, while P. R. Mallory specifies "below 0.5 percent carbon maximum."

Arc Melting

When producing ingots in this way, the sponge is melted in a water-cooled copper container, using a tungsten, titanium, or some other type of electrode. Battelle Institute has used an arc furnace with a water-cooled tungsten electrode for

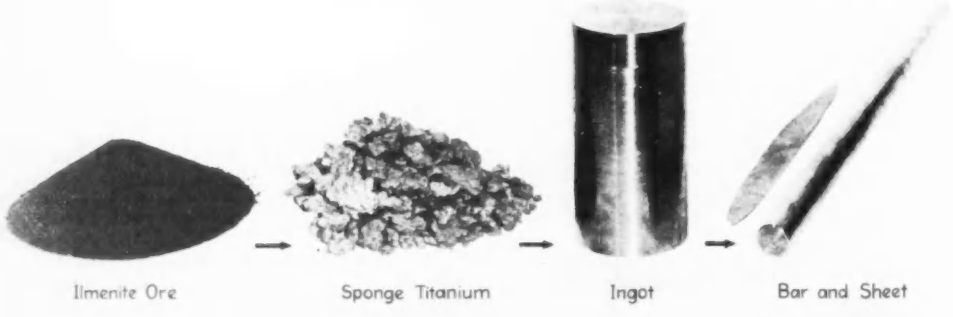


Fig. 5 — **Steps in the production of titanium. Ilmenite is reduced to sponge metal, which then is melted into an ingot for the production of rod and sheet.**

much of their experimental work. The Watervliet Research Laboratory of Allegheny-Ludlum Steel Corporation also uses a modified arc furnace for ingots up to 100 lb in weight, and within the next few months will go to larger sizes ranging between 400 and 600 lb in weight. A 65 lb ingot arc melted by Allegheny-Ludlum is shown in Fig. 4.

A method of producing titanium developed at Battelle involves the continuous production of titanium or titanium alloy ingots, employing magnesium and titanium tetrachloride as the raw materials. Actually, the continuous production of the titanium ingots involves two steps carried out in a single, integrated unit as follows:

Step 1. The continuous addition of liquid magnesium to a titanium tetrachloride atmosphere in a reaction chamber where these two reactants unite to form titanium and magnesium chloride at a temperature preferably about 1400 to 1600 F. This reaction product consists of about 88.5 percent liquid magnesium chloride and 11.5 percent solid titanium particles by volume. The reaction product is not accumulated in the reaction chamber, but is permitted to run continuously from the bottom directly into an arc furnace where the second step is carried out.

Step 2. In the arc furnace, the titanium is melted and the magnesium chloride and unreacted magnesium is volatilized, condensed, and removed from the furnace chamber while the continuously formed titanium ingot is withdrawn from the bottom of the furnace.

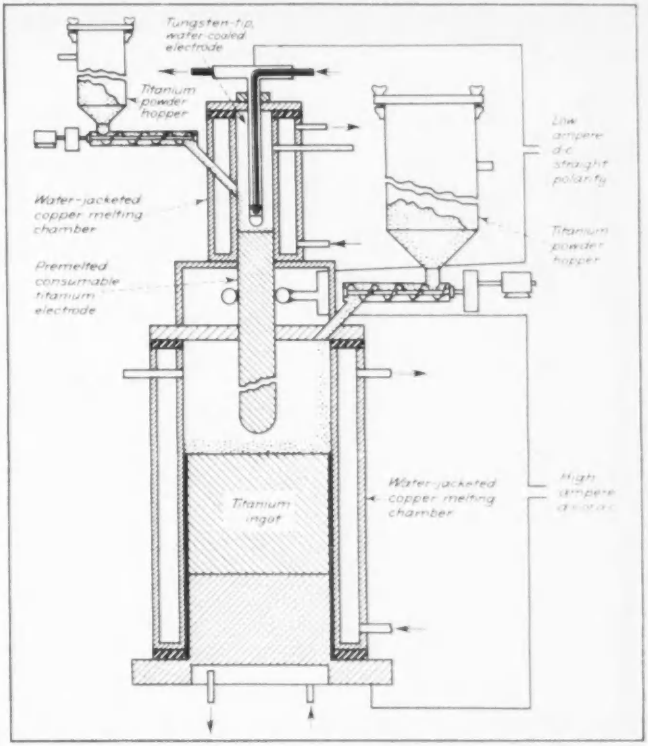


Fig. 6 – Proposed electric arc-furnace using a consumable titanium electrode to minimize tungsten contamination of the melt. Smaller versions of this design have been tried in the laboratory.

The feasibility of both steps of the process has been fairly well demonstrated in the laboratory. The first step is readily carried out because it merely involves the continuous addition of a stream of magnesium into

Table II – Mechanical Properties of Titanium Produced by Different Methods

MECHANICAL PROPERTIES	IODIDE TITANIUM		SINTERED (Magnesium-reduced)		SHEATH ROLLED[1] (Magnesium-reduced)		INDUCTION MELTED (Magnesium-reduced)		ARC MELTED (Magnesium-reduced)
	Annealed	50% Cold Worked	Annealed	40% Cold Worked	As rolled	40% Cold Worked	Annealed	50% Cold Worked	Annealed
Tensile strength, psi	38,000-48,000	97,000	79,100	122,000	97,600	129,000	80,000	115,000	70,000-80,000
Yield strength (0.2% offset), psi	20,000-24,000	87,000	64,000	113,300	75,000	111,500	72,000	105,000	58,000-68,000[2]
Proportional limit, psi	10,000		58,800	84,400	58,000	75,600	38,000		
Elongation in 2.0 in., percent	40 (in 1.0 in.)	11 (in 1.0 in.)	24.7	7.5	15.1	2.6	25	12	28-30
Reduction in area, percent	75	75					55	30	Up to 75
Modulus, 10^6 psi	14.0-15.5		16.8				16.0-16.5	14.5-16.5	14.5
Hardness, Brinell	73		185				228	282	

(1) At 1450 F (2) 0.1 percent offset

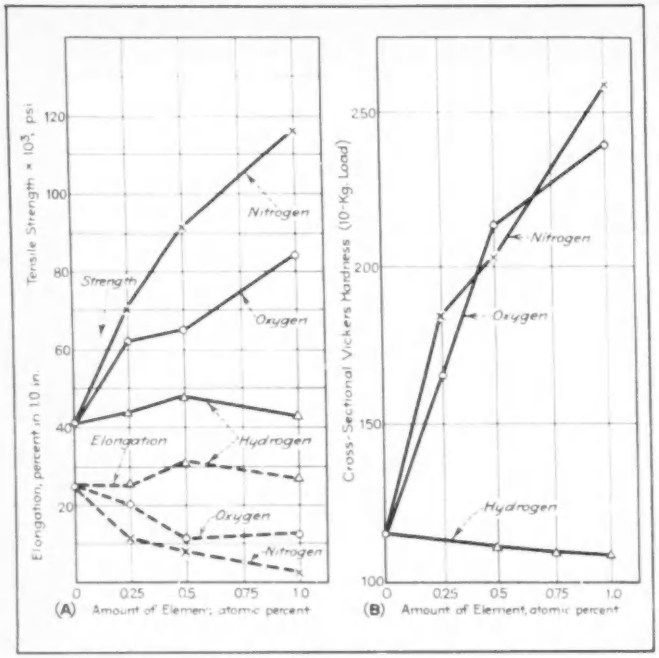


Fig. 7 **— How gaseous additions affect the strength and elongation (A) and the hardness (B) of iodide titanium. Carbon also has some effect on these properties.**

a chamber filled with titanium tetrachloride vapor.

Laboratory tests on the second step in the process have shown that titanium suspended in the liquid magnesium chloride can be melted as easily in the arc furnace as granular titanium sponge added alone. It is very important, however, that the reaction product be anhydrous which, of course, it would be if it were made by this method. Since this method of making titanium is a novel one, it is fully covered by applications for patents, under which the Federal Government would have free licenses.

Some tungsten contamination of the melt does occur with a water-cooled tungsten electrode. The use of consumable electrodes can overcome this difficulty. Consumable electrodes could be obtained by pressing the titanium powder into the desired shape either with or without a subsequent sintering operation, or by sintering alone, or by using a premelted solid titanium bar with an additional powder feed. In Fig. 6 is a schematic diagram of an apparatus suggested by Battelle Institute for utilizing the latter possibility.

There is some difference in the properties of titanium as prepared by different refining and melting methods. Whether the metal is prepared by the iodide process, by the Kroll process, or by a modification thereof influences the mechanical properties of the material. Also, whether the metal is arc melted, melted by induction in a graphite mold, or pressed and sintered influences the properties that are obtained. These differences are illustrated in Table II.

Actually, the difference in properties obtained by the various methods are a result of the impurities in the metal – largely nitrogen, oxygen, carbon, and tungsten. Tungsten is no problem if induction melting in a graphite crucible is the chosen method of reducing sponge or powder to ingot form, but carbon pick-up is on the order of 0.25 to 0.80 percent. On the other hand, carbon is no problem if the metal is melted in a copper-lined, water-cooled, arc furnace, but tungsten contamination from the electrode may exist (although not in the ingot for which the values are listed in Table II). Although the iodide process is generally considered to be of limited commercial value, it does produce titanium of the greatest purity. It is for this reason that the strength values are lower and the ductility is greater than for material made by any of the other processes. In other words, it is a "pure" metal, contaminated only in small amounts by alloying elements.

The effect of carbon, nitrogen, oxygen, and tungsten on the properties and workability of titanium have been shown to be considerable. In relatively small amounts (above 0.25 percent) carbon is insoluble in the solid state, so that carbide occurs in the form of tiny globules in the wrought metal. It is difficult to find out how much carbon can be tolerated. Some investigators state that even in small amounts it has a deleterious effect on ductility. Others say that carbon contents ranging from 0 to over 1.0 percent has a negligible effect on both strength or ductility. The general consensus is that carbon should not exceed 0.5 percent, and this much is known: that titanium low in carbon, nitrogen, and oxygen can be formed, extruded and drawn into wire or subjected to other severe fabricating techniques without cracking.

The effect of the gaseous additions on the tensile strength and elongations of iodide titanium is shown in Fig. 7. Quoting from the Air Force Project Rand Report, prepared by Battelle Institute:

"Nitrogen has a considerably greater strengthening effect on iodide titanium than oxygen, increasing the tensile strength almost threefold, while for oxygen the increase was about twofold. Nitrogen correspondingly decreases the ductility to a greater extent. Hydrogen appears to have a very slight strengthening effect, although this indication may be the result of variations in the initial material.

"Determinations of cold-rolling characteristics indicate nitrogen is more deleterious to cold rollability than oxygen. The work-hardening characteristics of titanium-hydrogen alloys are similar to those for pure titanium."

Table III – Comparative Mechanical Properties of Titanium, Stainless Steel, and Aluminum Sheet[1]

PROPERTY	UNALLOYED TITANIUM			SAE 1015 STEEL	STAINLESS STEEL AISI Type 302		24S-T Aluminum	75S-T Aluminum	MAGNESIUM ALLOY
	Annealed	½ Hard	Full Hard	(Annealed)	Annealed	½ Hard			AZ-31x-h
Ultimate tensile strength, psi	80,000	115,000	125,000	62,000	87,000	150,000	67,800	80,000	43,000
Yield strength, psi (0.2 percent offset)	72,000	105,000	110,000	42,000	37,000	110,000	41,000	72,000	32,000
Elongation, percent in 2.0 in.	25	14	12		55-60	15	23	13.5	
Density, lb per cubic in.	0.162			0.283	0.286		0.101	0.101	0.064
Modulus of elasticity, psi	15×10^6			29×10^6	28×10^6		10.5×10^6	10.4×10^6	6.5×10^6
$\frac{\text{Ultimate strength}}{\text{Density} \times 10^4}$ at									
Room temp.	488	701	763	219	306	528	672	792	672
400 F	318	520	586		238		276	405	
800 F	220	275	326						
1000 F	100	140	122						
$\frac{\text{0.2 percent Yield}}{\text{Density} \times 10^4}$ at									
Room temp.	438	640	671	148	131	389	406	713	500
400 F	214	500	460		122		208	394	
800 F	146	257	312						
1000 F	78	110	107						
$\frac{\text{Modulus}}{\text{Density} \times 10^6}$ at room temperature	90			102	98		104	103	101
$\frac{\sqrt{\text{Modulus}}}{\text{Density}}$	24,000			19,800	18,000	13,800		31,600	39,800
$\frac{\sqrt[3]{\text{Modulus}}}{\text{Density}}$	1,500			1,080	1,100			2,200	2,920

[1] – For magnesium-reduced, induction-melted titanium

MECHANICAL PROPERTIES OF TITANIUM

REGARDLESS of the method used to obtain the ingot, it is apparent that the tensile strength of unalloyed titanium in the annealed condition compares favorably with stainless steel and with the higher strength aluminum alloys as is shown on Fig. 8. But these comparisons do not tell the full story, because annealed, unalloyed titanium probably will be used only when cold-formability is of greater importance than strength. Strength can be increased considerably by cold working the metal, as shown in Table III, or by alloying it with other materials, as will be described in detail later.

Another advantage held by titanium over competing metals is its high proportional limit – on the order of 38,000 psi as against a maximum of 25,000 psi for fully worked austenitic stainless steels. Aluminum alloys do not have a true proportional limit. Only in heat-treated steels and in some of the aluminum bronzes is the proportional limit comparable, and the density of these metals is nearly twice that of titanium. Section for section, a considerable saving in weight can be obtained by the application of titanium, insofar as both tensile strength and proportional limit are concerned (Fig. 9).

Although the values commonly given for tensile strength and other mechanical properties are for annealed bars and cold rolled sheet, annealing is not ordinarily required for die forgings. A reduction in height of 77 percent can be achieved by forging at temperatures as low as 1450 F without the formation of tears, cracks, or breaks and without the necessity of subsequent annealing. As indicated in Table IV, the elongation in 2.0 in. of hot forged, unalloyed titanium is sufficiently high for most applications, and investigators report that titanium alloys will most certainly be used in the as-forged, rather than the annealed condition.

Sheet, on the other hand, will be used in the as-rolled annealed or cold worked condition. Annealing may be necessary to improve the formability of the material. Cold rolling increases the hardness and tensile strength and decreases the ductility, as shown by the curves of Fig. 10 for commercially pure titanium sheet. Although the curves are extended to the 60 percent line, most observers feel that 50 percent is a good maximum average for cold reduction, while others cling to the 40 to 45 percent level. Actually, not much improvement in strength is obtained above 45 percent, and hardness remains essentially the same.

One of the most attractive features of titanium is the strength at high temperature – up to at least 1,000 F, and in the alloyed condition, perhaps

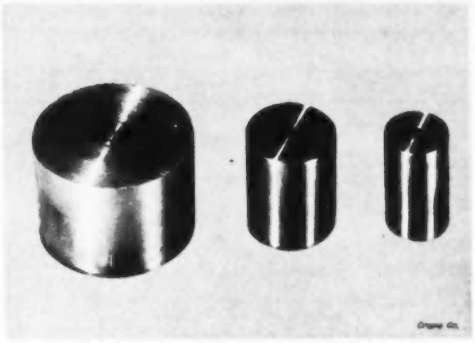


Fig. 9 (Above) — **Relative tensile strength of unalloyed aluminum, iron, and titanium. In the alloyed state, the tensile strength of titanium may reach 170,000-190,000 psi or higher.**

Fig. 8 — **Relative density of stainless steel, titanium, aluminum and magnesium. Each bar weighs one pound.**

as high as 1,200 F. Magnesium and aluminum alloys are not considered to have any useful load-carrying ability at temperatures above 600 F, whereas titanium is indicated to have useful creep strength at a temperature as high as 1,000 F. Comparative strengths of forged and annealed titanium bars and cold worked sheet at elevated and sub-zero temperatures are shown in Table IV. While this data does not indicate that titanium will replace the high temperature alloys developed for gas turbine work, even in the alloyed state, it does show that at temperatures up to 1,000 deg, titanium should find many interesting applications, especially since by alloying the Rockwell *A* hardness can be increased from 33 and 6 at 930 and 1,110 F to 49 and 27 respectively.

Where might this property be useful? In high compression engines, for one. Certainly for the skin of supersonic aircraft, for another. High temperature piping, gas turbine compressor blades, steam turbine reaction blading, rocket components, and equipment for the process industries are other possibilities.

Aircraft skinning is a particularly enticing possibility. At supersonic speeds, the skin of an airplane is heated by the friction of the air as it sweeps over the wings and along the fuselage. Since aluminum alloys, which have been used in the past, have poor strength at 600 F or above,

Table IV — Mechanical Properties of Commercially Pure Titanium at Various Temperatures[1]

TEMPERATURE F	MATERIAL		MECHANICAL PROPERTIES					
	Form	Condition	Tensile Strength, psi	Yield Strength, psi (0.2% offset)	Elongation in 2.0 in, percent	Reduction in Area, percent	Charpy V-Notch Impact, Ft-lb	Modulus of Elasticity, psi
75	Bar	Hot Forged	137,000	124,000	14	16	11	17.4×10^6
Room Temperature	Rod	Hot Forged	90,000	75,000	18	26	19	$16.0–16.5 \times 10^6$
		Annealed	80,000	72,000	25	55		
	Sheet	25% Cold Worked	115,000	105,000	14	35		
		50% Cold Worked	125,000	110,000	12	30		$14.5–15.5 \times 10^6$
400	Rod	Hot Forged	62,000	39,000	21	33	40	13.0×10^6
		Annealed	52,000	35,000	33	57		
	Sheet	25% Cold Worked	85,000	82,000	16	27		
		50% Cold Worked	96,000	75,000	18	38		$14.0–15.0 \times 10^6$
800	Rod	Hot Forged	47,000	33,000	15	53		14.5×10^6
		Annealed	36,000	25,000	20	60		
	Sheet	25% Cold Worked	45,000	42,000	44	58		
		50% Cold Worked	53,000	51,000	46	65		$13.0–14.0 \times 10^6$
1000	Rod	Hot Forged	34,000	24,000	43	60		12.0×10^6
		Annealed	16,000	15,000	77	96		
	Sheet	25% Cold Worked	23,000	18,000	48	84		
		50% Cold Worked	20,000	17,500	79	—		$10.5–11.5 \times 10^6$

1. Short time temperature tests (½ hr at temperature). Rate of loading 0.05 in. per minute.

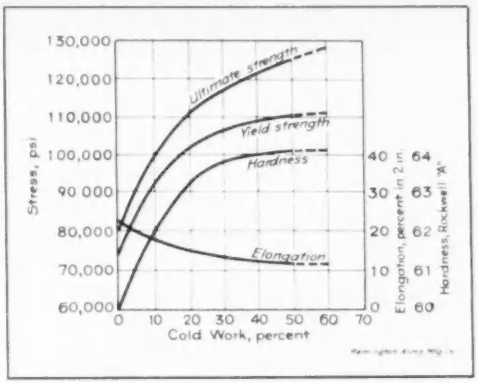


Fig. 10 — **How cold working changes the mechanical properties of commercially pure titanium sheet. Not much is gained by work hardening above 45 to 50 percent.**

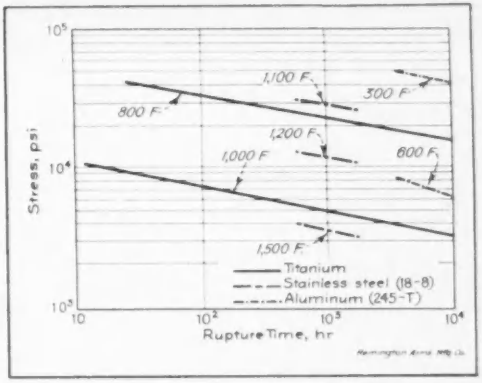


Fig. 11—**Stress rupture data for unalloyed titanium, stainless steel, and 24S-T aluminum. At 800 F, the stress rupture value is about 32,000 psi.**

to get around that limitation, the aircraft manufacturers investigated stainless steel. Its resistance to high temperatures is satisfactory, but to reduce the added weight, the skin had to be made so thin that trouble was encountered in riveting it and in securing sufficient buckling strength under high dynamic loading conditions. Titanium alloys are expected to fill the gap between these two metals.

Actual tests on forged titanium bar stock containing a maximum of 0.5 percent carbon show virtually no creep at 600 F under a stress of 25,000 psi; a creep rate of 0.000015 percent per hr at 800 F under a stress of 16,000 psi; and a creep rate of 0.00012 percent per hr at 1,000 F under a stress of 2,000 psi. Tests on the same material indicate the 100 hr stress-rupture values for pure titanium to be 32,000 psi at 800 F and 7,400 psi at 1,000 F. Stress-rupture curves for unalloyed titanium and other materials are shown in Fig. 11.

There has been some conflict regarding the endurance limit of commercially pure titanium, some investigators reporting that the endurance limit is less than 30 percent of the tensile strength, as is normally encountered with non-ferrous materials. On the other hand, some laboratories report data that showed endurance limit about 70 percent of the tensile strength. This latter value is extremely high, considering that steel has a value of about 50 percent. The general consensus among du Pont, Remington Arms, and Battelle is that the actual figure is midway between the two.

Preliminary data on titanium sheet specimen at Remington Arms indicate an endurance limit of 55,000 psi at 10,000,000 cycles. The material used for the tests had an ultimate tensile strength of 130,000 psi and a 0.2 percent offset yield strength of 112,000 psi. Rotating beam fatigue tests on several samples of bar stock indicate that the endurance limit is approximately 50 percent of the ultimate tensile strength. Specimens with a sharp V notch show a corresponding endurance limit of approximately 25 percent of the ultimate tensile strength. The chart, Fig. 12,

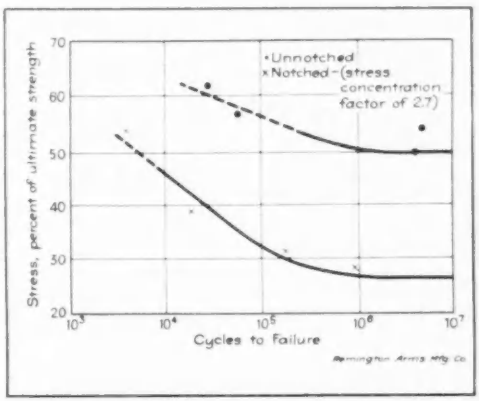


Fig. 12 — **Rotating beam fatigue curves for notched and unnotched specimens of unalloyed titanium.**

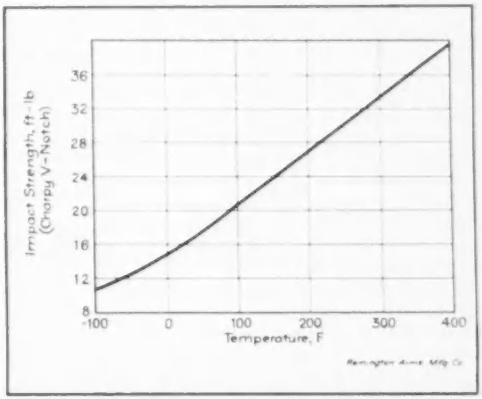


Fig. 13 — **Charpy V-notch impact strength of hot forged unalloyed titanium. This depends somewhat on the purity.**

Table V—Bearing Strength of Titanium and Aluminum Alloys

MATERIAL	PERCENT COLD WOFK	STRENGTH (psi)	
		Yield, 0.5 percent offset	Bearing Ultimate
14S-T aluminum	—	84,000	105,000
17S-T aluminum	—	56,000	93,000
24S-T aluminum	—	64,000	102,000
24S-RT aluminum	—	80,000	110,000
61S-T aluminum	—	55,000	72,000
Titanium	0	115,000	182,000
Titanium	0	119,000	172,000
Titanium	23.4	169,000	216,000
Titanium	46.8	183,000	220,000
Titanium	48.8	183,000	226,000

Table VI—Compressive Strength of Unalloyed Titanium

PROPERTY	FORM OF MATERIAL			
	BAR[1]	SHEET[2]		
	Hot Forged	Annealed	½ Hard	Full Hard
Ultimate strength, psi	95,000 (Buckling)			
Yield strength, 0.2 percent offset, psi	76,000	72,000	98,000	104,000[3]
Proportional limit, psi	56,000			
Modulus of elasticity, psi	17.5×10^6	16×10^6	15.5×10^6	15×10^6
Poisson's ratio	0.33			

1—Specimens ½ in. diameter x 2¾ in. long. 2—0.065 in. thick. 3—For 0.1 percent offset.

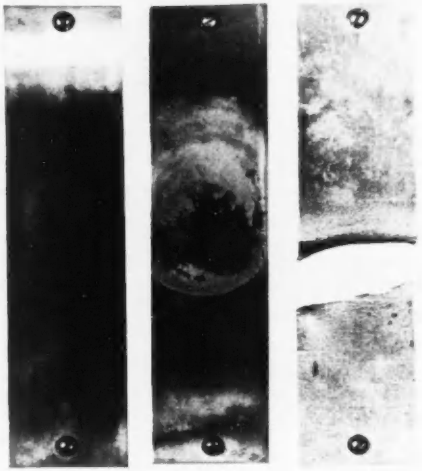


***Fig. 14*—Comparative tests in the Remington Arms Research Laboratories showed that titanium deteriorates less rapidly than stainless steel or aluminum under a 2200 F. flame**

shows S-*N* curves for notched and unnotched specimens.

Other interesting properties of titanium are shear strength and bearing strength, particularly because titanium may prove suitable for aircraft rivets. Pins of 3/32 in. diameter machined from annealed, hot forged bar stock have an average shear strength of 82,000 psi when tested according to the Wright Field standard method. Again, these values are for induction melted titanium containing a maximum of 0.5 percent carbon. A shear strength of 47,000 psi is the commonly accepted value for 75S-T aluminum when checked by the same method.

Bearing strength, also tested according to the Wright Field standard procedure—i. e., ¼ in. pin, 1⅛ in. strip, and an edge to pin distance of twice the pin diameter—is substantially better than most of the aluminum alloys, Table V.

Other mechanical properties, as reported by Remington Arms, are as follows:

Compressive strength is high, as shown in Table VI.

Impact strength is about 18 ft-lb, (Charpy V-notch) for unalloyed titanium at room temperature, Fig. 13.

Transverse properties of 50 percent cold-worked sheet are approximately the same as longitudinal properties. Tensile data indicates no significant difference.

Elongation at zero gage length is approximately 90 percent for annealed sheet.

Fire resistance, determined by exposing the metal to a 2,200 F flame for one-half hour, indicates that titanium is no more affected than stainless steel and is much better than aluminum. Results of one test are shown in Fig. 14.

Torsion properties of forged bar stock are as follows: A modulus of rigidity of 6.6×10^6 psi, a modulus of rupture of 79,000 psi, a yield strength at 0.2 percent offset of 56,700 psi, a proportional limit of 46,000 psi, and strain at rupture of 0.75 in. per inch.

Rockwell C hardness varies from around 14 for annealed material to about 30 for 70 percent cold worked stock. Detailed data on through hardening and surface hardening is covered in a later section on fabrication.

Preliminary damping tests on titanium by the Aviation Gas Turbine Division of the Westinghouse Electric Corporation indicate an energy dissipation of 0.25 percent at 30,000 psi, and 0.1 percent at 20,000 psi.

Summing up mechanical properties, it is apparent that the properties of titanium indicate that it will fill a gap that now exists between the light metals, such as aluminum and magnesium, and the heavier alloys, such as stainless steel and the nickel bearing material. The properties have not as yet been thoroughly investigated or substantiated to, particularly since what one researcher reports may be for titanium containing substantial carbon contents, while what another concludes may be based on pressed and sintered metal or on arc melted metal. Actually, the serious work on creep strength, fatigue strength, corrosion resistance and other long-time tests is just getting under way. But preliminary results certainly warrant additional and intensive development not only by the producers but by concerns to whose products it may prove adaptable. As a matter of fact, many extensive investigations are already under way, but, being long time tests, they have not yet been productive of results.

Table VII—Comparative Physical Properties of Titanium and Other Metals

PROPERTY	MATERIALS						
	Titanium	Magnesium	Aluminum	75S-T Aluminum	18-8 Austenitic Stainless Steel	Iron	Copper
Atomic number	22	12	13			26	26
Atomic weight	47.90	24.32	26.97			55.85	63.57
Transformation	1615 F			None	None		
Density (66F)—Grams/cc	4.54	1.74	2.70	2.80	7.92	7.87	8.96
Lbs/cubic in.	0.162	0.061	0.095	0.101	0.286	2.77	3.15
Melting point, F	3140	1200	1220			2800	1980
Linear coefficient of thermal expansion (in./deg. F)	5.0×10^{-6}	13.8×10^{-6}	13.5×10^{-6}	12.7×10^{-6}	9.5×10^{-6}	6.88×10^{-6}	9.7×10^{-6}
Thermal conductivity BTU/ft²/in/deg F/hr	105			835	115		
Electrical resistivity (Microhm-cms)	60	4.33	2.65			9.71	1.67
Electrical conductivity	3.2% I.A.C.S.			30% I.A.C.S.	2.5% I.A.C.S.		
Modulus of elasticity	15×10^6	6.5×10^6	10×10^6	10.4×10^6	28×10^6	29×10^6	16×10^6

PHYSICAL AND CHEMICAL PROPERTIES

As SHOWN in Table VII, the density of pure titanium is between that of aluminum and iron or stainless steel. This property, in conjunction with its high tensile strength, immediately suggests many uses, but is not the entire answer in applications where compressive loads are encountered. Thick sections of light materials are more resistant to buckling loads than thin sections of denser metals, so that structural parts having the same resistance to buckling usually are lightest when made of the lightest material. In other words, density alone often is the determining factor in many applications. Some terms in the equations showing the relative stiffness of columns of equal weight are:

$$\frac{E}{(\text{Specific gravity})^3 \times 10^6} \quad (1)$$

$$\frac{E}{(\text{Specific gravity})^2 \times 10^6} \quad (2)$$

$$\frac{E}{(\text{Specific gravity}) \times 10^6} \quad (3)$$

$$\frac{\sqrt{E}}{\text{Specific gravity}} \quad (4)$$

$$\frac{\sqrt{E}}{\text{Specific gravity}} \quad (5)$$

Comparisons of some of these values for titanium and for other materials previously were shown in Table III.

Thus, in the initial application stages, at least, when buckling is an important factor titanium probably will be considered as a replacement for steel and stainless steel rather than for aluminum or magnesium. This is borne out by the program of the Naval Bureau of Aeronautics. Present plans are to first apply the material for compressor blades and discs in gas turbine engines, as shown in Fig. 15 and for aircraft fire walls, Fig. 16. For all of these components, stainless steel has been used up to now.

Another property of titanium that indicates replacement of stainless steel for some uses is its resistance to corrosion, which is said to be better than austenitic stainless steel, monel, and the cupro-nickel alloys, and as good as platinum in sea water. Samples of titanium made by the Remington Arms Company have been exposed to the following tests at Kure Beach, N. C.: jet aspirator; basin immersion; shore rack exposure (100 yards from water); and lot

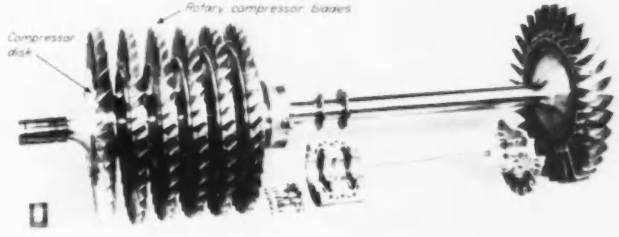


Fig. 15—**Compressor and turbine assembly for axial flow Westinghouse jet engine. Compressor blades and disks for later models will be made of titanium instead of stainless steel.**

TableVIII—Corrosion Resistance of Unalloyed Titanium to Chemicals

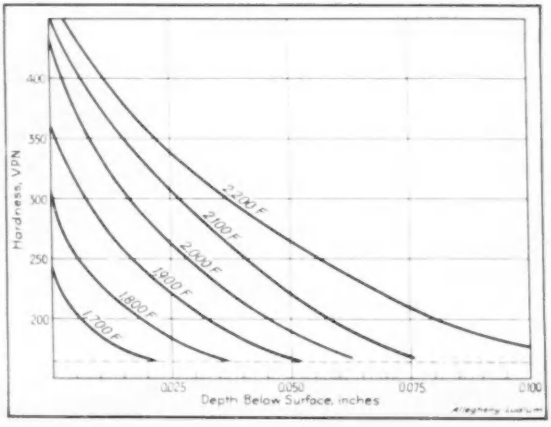
REAGENT	CONCENTRATION PERCENT BY WEIGHT	TEMPERATURE, F	RATING	REAGENT	CONCENTRATION PERCENT BY WEIGHT	TEMPERATURE, F	RATING
Acetic acid (glacial)	99	Boiling	A	Phosphoric acid	10	178	C
Acetic anhydride +	95				85	Room	B
Acetic acid	5	Room	A	Sodium chloride (saturated water solution)	–	Boiling	A
Ammonium hydroxide	28	Room	A	Sodium hydroxide	10	Boiling	A
Aqua regia ($3HCl–1HNO_3$)	–	Room	A		40	178	B
Aqua regia ($1HCl–3HNO_3$)	–	Room	A	Sodium hypochloride (5.6 percent Cl_2)	–	Room	A
Calcium chloride	28	Boiling	A	Sodium sulfide	10	Boiling	A
Carbon tetrachloride (1.0 percent water)	–	Boiling	A	Stearic acid	100	356	A
Chlorine gas (water saturated)	–	168	A	Sulfuric acid	1	Room	A
Chloracetic acid	30	178	A		1	Boiling	C
Chromic acid	10	Boiling	A		3	158	C
Cupric chloride	40	Boiling	A		5	Room	B
Ferric chloride	10	Boiling	A		5	Boiling	C
Formaldehyde	37	Boiling	A		10	Room	B
Formic acid	50	Boiling	C		10	158	C
Hydrochloric acid	1	158	A		40–104	Room	C
	1	Boiling	B	Sulfuric acid + Nitric acid	52 / 48	Room	A
	2	178	A	Sulfuric acid + Nitric acid + Water	14 / 83 / 3	Room	A
	3	158	B	Sulfur (molten)	100	464	A
	3	Boiling	C	Sulfur (water suspended)	–	Room	A
	5	Room	A	Trichlorethylene (unstabilized + 1.0 percent water)	–	Boiling	A
	5	158	B	Trichlorethylene (stabilized + 1.0 percent water)	–	Boiling	A
	5	Boiling	C	Water (chlorine saturated)	–	168	A
	10	Room	B	Water (hydrogen sulfide saturated)	–	Room	A
	10	158	C	Water (sulfur dioxide saturated)	–	Room	A
	20	Room	B	Zinc chloride	10	Boiling	A
	37	Room	C				
Hydrofluoric acid	1	Room	C				
Hydrofluoric acid (anhydrous)	100	Room	B				
Lactic acid	85	Boiling	A				
Nitric acid	65	Boiling	B				
	98	Room	A				

rack exposure (1000 yards from water). Titanium was completely resistant to attack under all these conditions of exposure. Commercially pure titanium was given four months of continuous immersion in sea water and compared with aluminum, stainless steel, monel, for like periods. Upon examination of the panels, the titanium was virtually unaffected by corrosion; there was no loss of weight, whereas the other materials were attacked.

Disks of titanium and these other materials then were rotated at high

Fig. 16—**Some manufacturers are making experimental use of titanium for aircraft firewalls in place of stainless steel.**

Fig. 17—**Effect of elevated temperatures on surface hardness of unalloyed titanium. Specimens heated in air for one hr at indicated temperatures.**



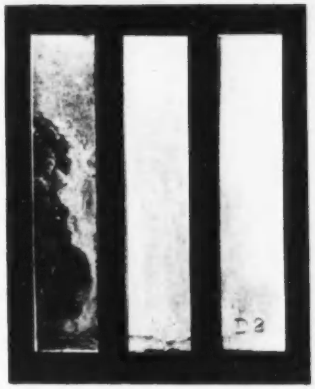


Fig. 18—**Comparative corrosion resistance of stainless steel, 52S aluminum, and titanium. Specimens were exposed to salt water for 600 hours.**

speeds for 60 days in sea water in a fully immersed test. Speed was such that velocity at the periphery was 27 fps. Here again, there was no loss of weight nor any signs of corrosion attack. This material appeared to be much better, for example, than cupro-nickel (currently used for condenser tubes). Outdoor exposure tests in marine environments gave the same results.

The behavior of commercially pure titanium in a number of chemical media also has been determined and rated. In Table VIII the letters, *A*, *B*, and C represent approximate corrosion rates as follows:

A. Titanium probably is suitable even though little dimensional change can be tolerated (corrosion rate less than 0.005 ipy).

B. Titanium probably is suitable where some corrosion can be tolerated; corrosion equivalent to that of materials now in common use for the application (corrosion rate 0.005-0.05 ipy).

C. Titanium probably is not suitable (corrosion rate greater than 0.05 ipy). In general it can be assumed that when the metal is entitled to a given rating at one temperature it is entitled to at least as high a rating at all lower temperatures. In addition to exposure to the chemicals listed in Table VIII, titanium also has been exposed for 600 hr at 190 F to onion juice in water, pineapple puice, cider-vinegar, lard, tea, coffee, grapefruit juice and lactic acid, with no visible effect. A 600 hr salt spray test also showed no visible effect, Fig. 18.

Insofar as other chemical and physical properties is concerned, it is interesting to note that pure titanium is an electrical resistor. In the pure state, it is not as high as Nichrome, but an alloy of 3 percent aluminum, 4 percent chromium, and a maximum of 0.5 percent carbon has an electrical resistivity of 141 x 10^{-6} ohms per centimeter as compared to 106 x 10^{-6} for Nichrome. Furthermore, this resistivity can be controlled, within limits, by heat treatment.

Whether this property will ever result in the widespread application of titanium for electrical or electronic resistors is somewhat in doubt, because long time exposure to air at elevated temperatures causes oxidation and embrittlement. Of course, many resistors operate near room temperature, and in such cases titanium would be practical. At temperatures of from 300 to 400 F, a gray adherent oxide and nitride coat is formed; at 1,000 F, the coating becomes dark gray in color, and above 1,000 F, an orange-yellow tinge becomes visible. Allegheny-Ludlum has charted the changes in surface hardness of unalloyed, carbon-free titanium at temperatures from 1,700 to 2,200 F. These curves, Fig. 17, which were based on a 1.0 hr exposure, indicated that even short time exposures may be harmful if the temperatures are in this range.

FABRICATION

TITANIUM and titanium alloys can be die forged, hot rolled, ground, welded, or swaged quite easily. Extrusion is reported to be practical. Machining is somewhat more difficult, as is drawing the metal into wire. Special techniques will have to be developed if the materials are to be adapted to casting. And cold forming can be done, but successfully only with high purity titanium; as a matter of fact, an entirely new fabricating technique, utilizing hot forming methods, will probably be developed to handle titanium with a carbon content in excess of 0.5 percent, and high strength titanium alloys.

Machinability

The machinability of titanium and titanium alloys is no better than that of austenitic stainless steel, and is often considered inferior to stainless steel by machinists who have worked with both metals. High speed steel tools have been tried, and Allegheny-Ludlum reports good success with their high speed steel grade LXX. Carbide tools, ground to the same rake angles as for stainless steel, are used by others. Carboloy A15-GI, Super Tool SL-75, and grades of similar composition of other manufacturers have held up fairly well. The depth of cut varies according to the condition of the specimen. If the specimen has rough and unclean surfaces the depth of cut is usually about 1/32 in. and does not exceed 3/32 in. On clean smooth surfaces the depth of cut may vary from 3/32 in. to 1/8 in. The most suitable speed for lathe

Table IX—Sawing Tests on Forged Titanium and 18-8 Stainless Steel

TESTING CONDITIONS				CUTTING TIME, SEC				
						TITANIUM		
Combination	Blade	Band Speed, fpm	Load	No. Tests	18-8 (Average)	High	Low	Average
A	14 tpi	45	Light	12	36	1,478	43	732
B	14 tpi	45	Light	12	23	832	60	371
C	14 tpi	130	Heavy	12	14	408	24	167
D	14 tpi	130	Heavy	12	11	207	35	89
E	10 tpi	45	Light	4	21	370	32	165
F	10 tpi	45	Light	4	14	313	48	141
G	10 tpi	130	Heavy	4	10½	105	28	69
H	10 tpi	130	Heavy	4	8	76	23	42

Tests made with a gravity feed band saw, using regular steel blades.
Test bars were $^{5}/_{8}$-in. rounds.
The titanium had been forged at 1900 F. The 18Cr-8Ni steel was in the annealed condition.

Fig. 19 — **Forged gear blank and disks. Both the pure metal and alloyed material have good forgeability. Note the absence of edge cracks.**

work is 400 rpm for material up to 2 in. dia and should not exceed 600 rpm. At speeds above 600 rpm the cutting edge of the tool is rapidly dulled, necessitating frequent grinding. Oils or other cutting lubricants are not recommended as they have not been found helpful. Fine turnings present a fire hazard as titanium in finely dispersed form is pyrophoric.

Grinding with a fine grit, soft wheel results in a good finish. Hard wheels load up and drag, or else they cut into and weld to the specimen causing the wheel to shatter. The material also can be cut-off wet using a thin (0.020 to 0.040 in.) wheel of similar grade.

Cut-off tests with a gravity-feed band saw indicate that titanium requires approximately 10 times as long to saw as annealed stainless steel, Table IX. Both titanium and austenitic stainless steel saw better with heavy feed loads and high band speeds. Coarse teeth (10 teeth per inch) cut faster than finer blades (14 teeth per inch). Variations in sawing times as great as 30 to 1 can be encountered in sawing titanium under ostensibly similar conditions, which indicates that titanium is more sensitive to wear or clogging of the saw blade than stainless steel.

Fig. 20 — **Conveyor link (A) and spanner wrench (B) forged of titanium in dies designed for plain carbon steel. But since the thermal contraction of titanium is less than that of steel, flash had to be trimmed on a grinding wheel instead of the existing trim dies.**

Drilling and tapping is difficult because the chips tend to weld to the specimen and to gall the tool. Carbide-tipped tools are recommended. More information on these operations will not be forthcoming until tests now under way are completed.

All external threads must be chased on a lathe because of the affinity of the metal for other materials. If dies are used to cut threads, the piece will weld directly to the die.

Forgability

Both alloyed and unalloyed titanium can be forged readily at temperatures between 1,500 and 1,800 F — better, as a matter of fact, than ordinary carbon steel. As yet, few limitations have been discovered, with one exception: If unalloyed titanium is heated to too high a temperature, a yellow oxide will form on the surface. For this reason, forging temperatures between 1,600 and 1,800 F are most satisfactory even though somewhat higher pressures are required. Some metallurgists cite 1,950 F as the upper temperature limit, but the formation of a heavy oxide film is certain at such temperatures. No protective atmosphere need be employed for forging, nor is there any limitation on the type of furnace that can be used.

The parts and disks shown in Figs. 19 and 20 indicate the possibilities of the forging process. The one part in Fig. 19 was made in a die for a steel gear blank; the other was simply flattened out under the hammer. No edge cracks are apparent either in the as-forged parts or on the machined forging, center.

The forgings in Fig. 20 are sample parts that again were formed in dies intended for carbon steel. The part at *A* was made in a die for a steel conveyor-pin, while that at *B*, in a die for a steel spanner wrench. Forging temperatures were 1,650 F, as compared with a temperature of 2,250 F required for the AISI 1045 steel parts. The only precaution that had to be observed was to pull the titanium part from the die while it was still hot. Since titanium has a thermal coefficient of expansion less than that of steel, it tended to "freeze" in the die if allowed to cool. Of course, allowance would be made for this fact in designing a forging die for titanium, and a trim die as well.

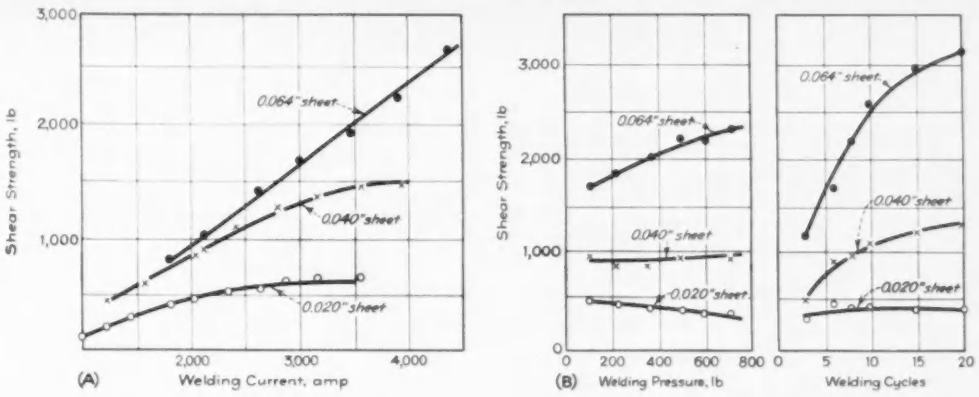


Fig. 21 — Effect of welding current (A) and welding time and electrode pressure (B) on the strength of spot welds in unalloyed titanium sheet.

The following quotation on forgability is taken directly from the Air Force Project Rand Report prepared by Battelle.

"Dynamic hardness tests have been made on plain carbon steel, 18Cr-8Ni steel, 24S-T aluminum alloy, and arc melted titanium samples at temperatures within the normal forging ranges for these materials. The method used was to make an impression simultaneously on a cold copper disc and on a hot specimen by an impact load exerted on a Brinell ball. The diameters of the two impressions were measured and hardness values calculated, using the known values for the hardness of the copper disc. Table X gives a comparison of the conventional and dynamic hardness over a range of forging temperatures for the four metals.

"The hardness data are believed to give useful indications of the energy required for plastic deformation at various temperatures. The relative hardness values of the three commercial materials agree with the general ideas on their forgability. It seems reasonable to conclude, therefore, that less energy is required to forge unalloyed titanium at 1650 F or higher than to forge the other materials. The titanium sample had a much higher hot hardness at 1,450 F by this non-standard testing method than it had at higher temperatures. When it is desirable to forge titanium at this subcritical temperature, forging pressures higher than those required for high-strength aluminum alloys at their normal working temperatures will probably be necessary."

Weldability

Titanium is welded easily by resistance welding methods. The range of welding conditions in spot welding is wider than can be tolerated on stainless steel, for example, and there is no sticking of the electrodes.

Dean, Long, Hayes and Root established the effect of resistance welding current, and welding pressure on unalloyed titanium sheet in three thicknesses in a paper published in the *Transactions* of the American Institute of Mining and Metallurgical Engineers. Results are shown in Fig. 21. However, for all of these welds, $\frac{1}{8}$ in. diameter electrodes were used, which is somewhat smaller than recommended by the AWS, and this fact probably affected the results somewhat.

Tests made by P. R. Mallory Co. on carbon-titanium alloys indicate that higher welding currents and pressures are satisfactory. The strengths of joints obtained by them under their separate conditions are listed in Table XI. In all tests, which were on 0.068 in. cold rolled sheet, an electrode having a tip radius of 3.0 in. was used. Photographs of the welds are shown in Fig. 22.

Other resistance welding methods also are satisfactory, including seam welding, projection welding, and flash and butt welding. Electric arc welding also can be performed with excellent results, although the heli-arc process or an argon shielded electrode must be used to prevent contamination of the metal by oxygen and nitrogen — and therefore embrittlement.

A strong welded joint, however, is difficult to obtain between titanium and a dissimilar material. Although such investigations are still in the

Table X—Dynamic Hardness of Arc-Melted Titanium and Other Materials at Forging Temperatures

MATERIAL	DYNAMIC HARDNESS[1] AT TEMPERATURE, F									
	Room	750	825	875	1450	1650	1800	1850	2000	2200
24S-T aluminum alloy	100	40	38	38	—	—	—	—	—	—
C1018 carbon steel	183	—	—	—	—	50	—	37	—	—
18Cr-8Ni steel	170	—	—	—	—	—	61	—	53	47
Unalloyed titanium	184	—	—	—	57	39	—	26	—	—

1—Simultaneous indentation by a Brinell ball on copper and sample. Hardness calculated from impression diameters and known hardness of copper. All values averages of three tests.

preliminary stages, results indicate that when titanium is spot welded to Everdur, Monel, or nickel, a coarse mixture of the two metals occurs at the weld area, there being no true fusion or joint. When welded to 18-8 stainless steel, the NAX low carbon steels, or Inconel, a brittle weld nugget is obtained. Experiments now being conducted with pulsation welding, pre-heating, post-heating and with a sandwich joint using another material may provide the answers to some of these problems.

Titanium can also be brazed in controlled atmosphere brazing furnaces. These tests, in which a nickel-solder was used, resulted in an excellent joint, with about the same restrictions on design as with other materials.

Extrusion

From the plasticity standpoint, titanium should extrude nicely. The major problem that may be encountered is concerned with its tendency to "wet" a mating surface: It may weld to the extrusion die.

However, valves for reciprocating engines have been made in the same dies used for impact extrusions of steel. These were simply experimental tests to determine the possibilities of extrusion. No particular difficulty was encountered.

The Bohn Aluminum & Brass Corporation in Detroit is experimenting with extrusion, but results have not been released, as the following telegraphic copy from a McGraw-Hill editor in Detroit states:

"BOHN WILL RELEASE NOTHING ABOUT TITANIUM. ENTIRELY EXPERIMENTAL NOW. EXPERIMENTS INDICATE EXTRUSIONS MAY REACH TENSILE STRENGTH 150,000 PSI. COSTS PROHIBITIVE, OVER 100 TIMES THAT OF ALUMINUM ALLOYS. NO COMMERCIAL APPLICATIONS INDICATED. PRESENT EXPERIMENTAL ALLOYS CONTAIN ABOUT 3 PERCENT ALUMINUM AND 5 PERCENT CHROMIUM."

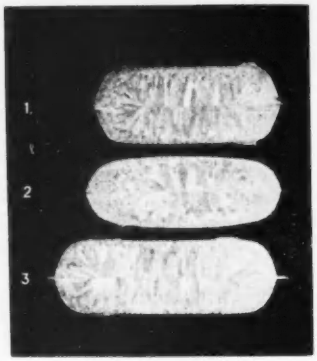


Fig. 22 – Spot welds in alloyed titanium sheet. The welds were made under the conditions shown in Table XI.

The significant fact about the telegram is, of course, that it indicates that Bohn has had considerable success with extruding the material. The costs are tied up directly with the cost of the metal. When those costs come down, there will be significant commercial applications.

Casting

In general, the problems encountered in casting titanium are of a sufficient magnitude to limit the usefulness of this production method. Investment casting is a possibility, but (1) titanium must be melted and cast in an inert atmosphere; (2) no good refractory material has as yet been found; (3) the as-cast properties of the material are not as good as those obtained by forging or some other production method; and (4) investment casting is economical only for intricate, small parts. All these difficulties would be magnified if larger castings were to be attempted.

Bending and Forming

Annealed titanium in sheet form, 0.020 in.–0.070 in. thick, will take a 2*t* minimum bend radius; ½ hard titanium will take a 4*t* minimum bend radius. It appears to be completely practical to brake form titanium, but considerable development work remains to be done on drawing, cupping, spinning, die forming, and roll forming. Most of those latter operations probably will have to be done hot, especially if the operation is severe or if the metal is high in carbon content.

Heat Treatment

Annealing–Titanium can be satisfactorily annealed by heating at 1,300 F for one hour for forgings or bars and 15 min. for sheet – or less at higher temperatures. A stress-relief anneal can be performed by heating at not over 570 F in air for one hour. Stress-relief anneal of cold worked titanium will increase the minimum bend radius.

Exposure to a temperature of 800 F for 1,000 hr will completely remove cold worked properties from titanium. As with other metals, shorter times at higher temperatures will also remove the cold work. Annealing can be done in air; an argon or helium atmosphere is unnecessary and probably without benefit. Although the hardness of annealed sheet does not drop appreciably from the cold worked condition, neither are there any appreciable changes in microstructure, although the grain size may be slightly increased over the size in the as-rolled condition.

Surface hardening–This phase of research has not been completely developed as yet, but preliminary findings are these: It is difficult to prevent some oxygen pick-up when hot working titanium or titanium alloys, and as a result some surface hardening occurs. The materials can be oxidized, nitrided, or hardened by other conventional surface hardening techniques. Hardening is particularly important for titanium and titanium alloys, since in the untreated state, they gall and seize to mating parts when used as "wear" surfaces.

Swaging

Titanium is difficult to work by swaging as it seizes on the dies. Before swaging, it must be heated in air to between 1500 and 1700 F to form a layer of oxide on the surface; this oxide acts as a lubricant between the metal and the die.

Table XI–Strength of Spot Welds in Carbon-Titanium Alloy

No.	Weld Current, Amp	Weld Diameter, in.	Heat Zone Diameter, in.	Penetration Percent	Strength lbs.
1	8,000	0.266	0.290	77	2,700
2	9,000	0.285	0.300	82	2,900
3	10,000	0.310	0.335	90	3,400

Welding time–10 cycles
Welding force–1,000 lbs.
Welder capacity–100 KVA
Welding current–9,000 amps
Electrodes–RWMA Class No. 2
Welder control–Synchronous

Table XII—Potential Alloying Elements for Titanium (Periodic Chart of Elements)

GROUP I		GROUP V	
Lithium Sodium Potassium Copper Rubidium Silver Caesium Gold Virginium	No outstanding alloy of titanium has yet been developed either with these elements used alone or in conjunction with some of the other elements in other groups. Copper is the only one that appears to have any possibilities.	**Nitrogen** Phosphorus **Vanadium** Arsenic Columbium Antimony Tantalum Bismuth Protoactinium	Vanadium may be used in some ternary and quaternary alloys. Columbium and tantalum are not outstanding. Nitrogen is useful in lesser amounts, which is fortunate because it is difficult to keep out.
GROUP II		GROUP VI	
Beryllium Magnesium Calcium Zinc Strontium Cadmium Barium Mercury Radium	Beryllium does not produce binary alloys of interest, but it may be useful in complex alloys as a minor addition. None of the other elements appears promising even though some work has been done with them and investigations are still continuing.	**Oxygen** Sulphur **Chromium** Selenium **Molybdenum** Tellurium **Tungsten** Polonium Uranium	Chromium and molybdenum are two of the best alloying elements yet found. Tungsten may turn up as a minor element in complex alloys. Oxygen is somewhat like nitrogen. Sulphur and selenium are not quite so good.
GROUP III		GROUP VII	
Boron **Aluminum** Scandium Gallium Yttrium Indium Rare earths Thallium Actinium	Boron alloys have fairly good strength and ductility; and aluminum-chromium and aluminum-iron look very promising, both having fairly good hardness strength and oxidation resistance at elevated temperatures.	Fluorine Chlorine **Manganese** Bromine Masurium Iodine Rhenium Alabamine	Manganese ranks right alongside of chromium in possibility. It is slightly soluble in alpha and more soluble beta titanium and hardens and strengthens with some reduction in ductility.
GROUP IV		GROUP VIII	
Carbon **Silicon** Titanium Germanium Zirconium Tin Hafnium Lead Thorium	Zirconium has a mild effect on strength and hardness, but the alloys are not outstanding. Silicon may be a useful additive in small amounts. Indium is not too good as a strengthener. For carbon, see text.	**Iron** Cobalt Nickel Ruthenium Rhodium Palladium Osmium Iridium Platinum	Iron probably will be an alloying element in complex alloys. Cobalt results in very brittle alloys. Nickel has much the same effect as cobalt, and is difficult to alloy. The other elements in this group are not practical as alloying additives.

TITANIUM ALLOYS

IF AND WHEN titanium becomes an important structural metal, much of it probably will be used in the alloyed condition because:

(1) Tensile strengths can be increased materially, from say 115,000 psi for pure titanium in the ½ H condition to 160,000-190,000 psi for alloyed titanium. Some alloys have been developed with strengths as high as 230,000 psi, although with negligible ductility.

(2) Ductility of some of these alloys is equal to and in many cases better than that of pure titanium in the cold worked state. The Allegheny-Ludlum Steel Corporation has found several alloys with a tensile strength of 150,000 to 160,000 psi, an elongation in 1.0 in. of 18 to 20 percent, and a reduction in area of around 40 percent.

(3) While overall resistance to corrosive attack may be lowered slightly, corrosion resistance to specific acids and chemicals may be increased in certain alloys.

(4) Titanium alloys age harden in the hot rolled condition, it being quite possible to age harden them up to 75 Vickers.

(5) At least one concern has developed an alloy that can be precipi-

Table XIII—Comparison of Hot Hardness of Aluminum-Chromium Alloy With Other Alloys of Titanium

ALLOY	COMPOSITION	CONDITION	HARDNESS, ROCKWELL *A*						
			Room	230 F	390 F	570 F	750 F	930 F	1110 F
Aluminum-Chromium-Titanium	3% Aluminum, 5% Chromium 0.5% Carbon, Small amounts of *C*, N_2, and O_2	Forged	71	68	65	61	58	47	27
		As quenched	75	72	69	65	60	52	20
Titanium-Carbon	0.5% Carbon	Forged	63	57	52	49	43	33	6
Chromium-Carbon-Titanium	4% Chromium, 0.8% Carbon	Forged	72	69	65	58	50	42	0
Aluminum-Carbon-Titanium	4% Aluminum, 0.6% Carbon	Forged	72	69	64	59	52	44	32

tation hardened without excessive loss of ductility.

(6) Titanium alloys should be no more expensive than unalloyed titanium.

(7) Some titanium alloys have much better resistance to oxidization at elevated temperatures than does commercially pure titanium.

(8) Of all the alloys investigated, not one with outstanding properties has been found that does not have excellent forgability.

(9) Hot hardness is increased materially by some alloying elements.

(10) The electrical resistivity of some titanium alloys is considerably higher than of the unalloyed metal.

(11) Most alloys need not be annealed or cold worked to obtain the desired properties.

These plus other possible advantages mentioned earlier indicate that the field for titanium alloys will be broad.

Most of the work being done at the present time is directed at investigating the properties of the most likely alloy composition. The Batelle Institute, for example, working with the Materials Laboratory, Wright-Patterson Air Force Base, has issued a preliminary report on approximately 400 alloy composition. From this group, one outstanding general purpose will be chosen, and perhaps five or six more will be selected as advantageous for certain special purpose applications. Those alloys then will be checked thoroughly for fatigue strength, resistance to corrosion, formability, creep strength, and other properties—such data as has not yet been obtained in the preliminary phase of the work.

This report, plus work by other concerns and laboratories working under government contract or independently, has fairly well established which alloying elements are potentially promising and which appear unsatisfactory. All of the good alloying elements appear to lower the alpha and beta solidus line of the titanium-alloy diagram. In addition, these alloys are soluble in the solid state, at least over a part of the composition. Examination of the elements as grouped in the periodic chart, Table XII, shows the following:

Group I – Copper increases hardness rather mildly. It definitely is not the best hardening or strengthening alloy yet found, and if used at all, will be in limited amounts. Lithium, sodium, potassium, and the others are too volatile to alloy easily or else have been found unattractive as alloys for titanium.

Group II – Most of the elements in this group are not easy to alloy. Beryllium has been investigated, but does not form a particularly good alloy since it forms an insoluble, intermetallic compound with titanium. However, it may be useful in small amounts of say 0.1 percent or so, to improve working and annealing characteristics. Cadmium, calcium, zinc, strontium, and magnesium probably will not be used.

Group III – Of the elements in this group, only boron and aluminum may have any usefulness, the others being either too volatile or on the rare side. Boron is somewhat like beryllium, being insoluble in the solid state, and forms intermetallic compounds. Although one investigator sees limited use for this element even in small amounts, another stated that a boron-titanium alloy has good oxidization resistance, and fairly good strength and ductility. Its electrical resistivity, from 58 to 68 x 10^{-6} ohms per centimeter, is on the order of pure titanium. However, it's doubtful that boron will ever be more than a secondary alloying element.

Aluminum is receiving considerable attention. One of the most interesting alloys developed by P. R. Mallory consists of 3.0 percent aluminum, 4.0 percent chromium, and 0.5 percent carbon maximum. Alloys of aluminum and iron also are receiving some attention. Aluminum increases hardness and oxidization resistance at elevated temperatures, and is a good strengthener.

Group IV – Zirconium forms a complete series of solid solution alloys. It is soluble up to about 1.0 percent in the solid state and has a relatively mild effect on strength and hardness. The same is true for tin and lead, except they are soluble up to several percent. Silicon may be a useful additive in small amounts. Alloys containing up to 1.0 percent silicon and 0.47 percent carbon have a tensile strength of 121,000 psi, an elongation in 2.0 in. of 12 percent, and good resistance to oxidization at elevated temperatures. With $1^1/_2$ percent silicon, $1^1/_2$ percent manganese, 0.47 percent carbon, and the remainder titanium, there is some embrittlement. Thus while silicon may be useful in amounts less than 1.0 percent, the tendency of the element to cause embrittlement in amounts greater than this probably will limit its use.

Carbon has a hardening and

strengthening effect on titanium when present in small amounts. This fact is fortunate because it is difficult to eliminate carbon entirely especially when melting in graphite crucibles. Actually, carbon is soluble in the beta phase up to about 0.1 percent, and in alpha titanium up to about 0.25 percent. Another interesting fact about carbon is this: by itself, it does not change the properties of pure titanium appreciably when present in small amounts; but when used with other elements in more complex alloys, it has a greater effect.

An indium-carbon-titanium alloy containing about 5.0 percent total alloying content is somewhat stronger than a carbon titanium alloy, and has good oxidization resistance at 1650 F, but the hot hardness of such an alloy is not too good.

Group V—Columbium and tantalum have been investigated. Suffice it to say that they are not outstanding as alloying elements.

Nitrogen is a useful element when present in amounts not exceeding 0.25 percent. Again, it would be unfortunate if such were not the case, because even with vacuum or inert atmosphere melting, it is difficult to keep out. It is soluble in far greater amounts than can be tolerated; it embrittles the metal when present in large quantities.

Vanadium is a good alloying element in many respects. A 1.0 percent alloy, for example, has a tensile strength of approximately 120,000 psi and an elongation in 2.0 in. of 23 percent. This ductility is better than that obtained with most other elements. Another advantage is that the alloy is quench hardenable, and can be softened once it has been hardened. However, it does not have outstanding hot hardness characteristics nor very good oxidization resistance at elevated temperatures.

With 5.0 percent vanadium, one specimen developed a tensile strength of 174,000 psi and an elongation of 4½ percent in 2.0 inches. In the as forged condition, the strength was 140,000 psi.

Group VI—Two of the best alloying elements found so far for titanium are in this group. They are chromium and molybdenum, and indications are that they will be major alloy additions. Both increase

Table XIV—Mechanical Properties of Some Miscellaneous Titanium Alloys

ALLOY	APPROXIMATE COMPOSITION, percent	CONDITION	TENSILE STRENGTH psi	YIELD STRENGTH psi	ELONGATION IN 1.0 IN. percent	HARDNESS
Tungsten-Carbon-Titanium	1.5 W, 0.15 C,	As forged	131,000	119,000	21.5	27 R_c
		HTQ	122,500	102,500	12.0	42 R_c
	2.0 W, 0.04 C, 0.03 N,	As forged	130,000	117,500	19.0	26 R_c
		HTQ	120,000	102,500	6.0	33 R_c
	2.5 W, 0.25 C,	As forged	147,000	130,000	10.0	35 R_c
	3.8 W, 0.39 C,	As forged	169,000		11.5	32 R_c
	4.5 W, bal Ti+C+N	As forged	130,000	117,500	19.0	26 R_c
	4.7 W, bal Ti+C+N	As forged	198,000	177,000	2.0	
	8.5 W, bal Ti+C+N	As forged	165,000	130,000	<1.0	
Tungsten-Nitrogen-Titanium	1.41 W, 0.15 N	As forged	145,000		2.5	34 R_c
	1.88 W, 0.29 N	As forged	169,000		3.5	31 R_c
	1.69 W, 0.46 N	As forged	191,000		0	45 R_c
Aluminum-Titanium	1.0 Al, bal Ti+C+N	As forged	113,600		11.0	66 R_A
Iron-Titanium	1.0 Fe, 0.77 W, 0.098 N	Normalized	126,000		27.5	31 R_A
Vanadium-Titanium	4.8 V, bal Ti+C+N	Hot rolled	140,000		10.0	
Manganese-Aluminum-Titanium	2.41 Mn, 5.31 Al, 0.3 C	As forged	158,000	106,000	1.5	
Manganese-Carbon-Titanium	4.74 Mn, 0.4 C,	As forged	190,000		<1.5	72 R_A
Chromium-Tungsten-Titanium	4.8 Cr, 0.30 W, 0.13 N	Normalized	149,500			51 R_A
	9.6 Cr, 0.82 W,	HTQ	123,500		3.0	45 R_A
	10.3 Cr, 0.79 W, 0.27 C	HTQ	164,500		2.0	43
Chromium-Vanadium-Titanium	5.0 Cr, 1.0 V, 0.25 C	Hot rolled	171,900		5.0	336 Vickers
	5.0 Cr, 2.0 V, 0.25 C	Hot rolled	189,700		3.5	378 Vickers
	3.5 Cr, 2.0 V, 0.2 N	Hot rolled	177,200		6.0	382 Vickers
Chromium-Manganese-Titanium	3.5 Cr, 1.0 Mn, 0.25 C	Hot rolled	162,400		4.5	272 Vickers
	5.0 Cr, 1.0 Mn, 0.25 C	Hot rolled	177,200		4.5	317 Vickers
Chromium-Molybdenum-Titanium	5.0 Cr, 1.0 Mo, 0.1 N	Hot rolled	175,000		4.5	367
Chromium-Nickel-Titanium	5.0 Cr, 1.0 Ni, 0.1 N	Hot rolled	182,000		5.0	377
	5.0 Cr, 2.0 Ni, 0.2 N	Hot rolled	194,700		3.0	417
Molybdenum-Titanium	5.0 Mo, bal Ti+C	Hot rolled	81,500		0	
	10.0 Mo, bal Ti+C	Hot rolled	136,500	116,500	3.5	

strength and hardness, do not cause brittleness, and increase oxidization resistance at high temperatures. Of the two, chromium is slightly the better, having somewhat less effect on ductility than molybdenum.

A lot of information also has been gathered on tungsten. It is soluble in the solid solution, but does not appear to have nearly the same beneficial effects as chromium or molybdenum. Nevertheless, it may turn up as a minor element in complex alloys, especially if they are produced in an arc furnace with tungsten electrodes.

Oxygen, also in this group, is about the same as nitrogen when used as an alloying element, although perhaps not quite so good. In large quantities it causes embrittlement (above a fraction of a percent). In small quantities it hardens, strengthens, and causes some decrease in ductility. Although oxygen is present in all titanium alloys, metallurgists do not know exactly what amount – except that it is small – because no successful method has yet been devised for determining this fact.

Finally, sulphur and selenium are not useful as additives.

Group VII–In this group, manganese ranks right alongside of chromium in possibility. It is soluble in both alpha and beta titanium up to useful amounts (several percent) and also hardens and strengthens without harming ductility.

Group VIII – The status of iron as an alloying element is somewhat obscure. It has only limited solubility in titanium; while said to increase strength and hardness it has an adverse effect on ductility. But there may be something here that researchers are not talking about–iron and other elements in a complex heat-treatable alloy. At least three concerns are seriously investigating this, and reports are that a titanium alloy containing iron will soon be available in commercial quantities.

Cobalt is soluble in both alpha and beta titanium but while it also increases strength and hardness to some extent, it does not approach chromium, molybdenum or manganese in usefulness, and results in very brittle alloys. One cobalt-carbon-titanium alloy had a tensile strength of 128,000 psi and negligible elongation in 2.0 inches. It might be useful as a minor alloy addition in complex alloys, but that apparently will be the extent of its application.

Table XV–Mechanical Properties of Some Ternary and Quaternary Alloys (As forged)

ALLEGHENY-LUDLUM PROPRIETARY ALLOYS

Tensile Strength, psi	Elongation in 1.0 in	Brinnell Hardness	Reduction in Area, percent
234,000	1.0	400	11
205,000	7.0	388	22
180,000	13.0	352	25
172,000	15.0	341	39
150,000	20.0	320	41

Finally, nickel has much the same effect as cobalt. Nickel does not increase strength and hardness in proportion to ductility, the alloys being very brittle, as a matter of fact. Furthermore, alloys of nickel are difficult to melt in an arc furnace. The consensus of opinion: nickel will not be a major additive.

Summing it all up, here is the way the alloy picture looks at the moment:

(1) The maximum alloy content of any foreseeable alloy will be 7 to 10 percent, with the average probably closer to 5.0 percent.

(2) The following elements will probably constitute the major alloying additions; chromium, manganese, molybdenum, nitrogen, carbon and aluminum – perhaps silicon, boron, and iron. Oxygen they cannot get rid of, so it too will be present in small amounts.

Table XVI–Properties of Some Alloys Prepared at Battelle.[1]

Intended Composition, percent	Ultimate Strength, psi	Elongation % in 1.0 in.	Minimum Bend Radius
5 Mn. 0.25C	190,000	4	low
5 Cr, 0.1N	186,800	5	3t
5 Mn, 1W	190,700	5	3t
5 Cr, 0.25C, 0.1N..	183,200	6	3t
5 Cr, 2 Mn, 0.25C..	194,400	2	
3.5 Cr, 2 Fe, 0.25C.	190,700	6	3t
3.5 Cr, 2 Mo, 0.2N.	190,000	7	3t
6Mn, 0.1 N.....	173,500	8.5	
7.5 Mn, 0.25C...	220,000	2	

[1]–These alloys have the best properties when they are in the as-hot-rolled condition. However, some of the alloys are age hardenable in this temper but relatively little data are available for this condition. None of them appears to be benefited by a solution heat treatment.

(3) The search is on for a good heat-treatable alloy, and if the reluctance of metallurgists to talk is any criterion, that alloy certainly will contain iron as one of the alloying elements.

(4) When exhaustive tests are run on some of the alloys now in the development stage – tests on creep strength, fatigue strength, corrosion resistance, damping capacity, and others – some of the elements that do not now appear to increase strength and hardness may be important. But such alloys would be special purpose, not general purpose, materials.

Properties of Promising Alloy Combinations

From the hundreds of alloy combinations that have been tested, investigators are gradually narrowing down the field to the six or eight that have the best properties for general purpose use. Some of the most likely looking ones are the following:

Aluminum-Chromium-Titanium– Containing about 3.0 percent aluminum, 5.0 percent chromium, small amounts of carbon, nitrogen and oxygen (carbon about 0.5 percent; nitrogen, less than 0.1 percent; and oxygen, probably less than 0.09 percent) this alloy has a hardness of 70 to 73 R_c, a tensile strength of 175,000 psi, and an elongation in 2.0 in. of 6.0 to 8.0 percent. These properties are in the as-forged state. The electrical resistivity of this alloy is 141 x 10^{-6} ohms per centimeter, as compared with 106 x 10^{-6} ohms per centimeter for Nichrome. Thus, besides its potentialities as a structural material, it may also eventually be applied in electronic and electrical applications as a resistor.

This alloy has good hot hardness characteristics, as indicated in Table XIII and is one of the best alloys found with this characteristic. Although the nitrogen content of these alloys may have some bearing on hot hardness values, the values obtained indicate that the alloys can be used at higher temperatures than pure titanium and, in some instances, stainless steel.

When exposed to a temperature of 1650 F for 16 hours, this alloy increased in weight by 0.14 grams per square inch, which while good, is not

equal to a boron-titanium alloy or a silicon-titanium alloy, which increased by 0.02 and 0.04 grams per square inch respectively.

Chromium-Nitrogen-Carbon Alloy–This alloy, containing approximately 3½ percent chromium, 0.1 to 0.2 percent nitrogen, and 0.15 to 0.25 percent carbon, has a tensile strength of 190,000 psi, an elongation in 2.0 inches of 6.0 percent, and a bend ductility at 105 degrees of 3*t*. These are properties that have been obtained in the laboratory, and as such cannot be called typical. Not enough heats, in large enough melts, have been made to warrant such a generalization, but even so, the feeling is that they are good average values.

If the total alloy content is increased to 6.0 percent, a tensile strength of 220,000 psi can be obtained, but the elongation is only 2.0 percent in 2.0 inches.

Manganese-Silicon-Carbon Alloy–A ternary alloy of titanium consisting of 1.50 percent manganese, 1.33 percent silicon, 0.40 percent carbon, and balance titanium has high tensile strength but is not very ductile. The alloy is quench hardenable and can be softened from the quenched state. As water quenched from 1650 F, the alloy has a hardness of 76.5 Rockwell *A* (51 Rockwell C). It also has good resistance to oxidization in air at 1650 F: Heating a specimen in air for 16 hr at 1650 F produced an increase in weight on the order of 0.03 grams per square inch.

Other mechanical properties are as follows: reduction in area when forged at 1600 F, 79 percent; ultimate tensile strength, 150,000 psi; proportional limit, 95,000 psi; modulus of elasticity, 16.6×10^6 psi; elongation in 2.0 in., 2.4 percent; and hardness at 1110 F, 17 Rockwell *A* as forged and 27 Rockwell *A* as quenched.

Other Proprietary Alloys–Several alloys developed by Allegheny-Ludlum have excellent mechanical properties. Most of these are ternary and quaternary alloys, but the exact compositions have not been released. They range from ductile types having tensile strengths of 150,000 to 160,000 psi and an elongation in 2.0 in. of 15 to 20 percent to very hard and brittle grades with tensile strengths on the order of 230,000 to 235,000 psi. A representative range of properties is given in Table XV.

The alloy development work carried out at Battelle Memorial Institute for the Wright-Patterson Air Force Base has been largely exploratory in nature. About 300 alloys have been studied to date. These compositions are binary, ternary, and quaternary alloys of titanium with copper, boron, beryllium, carbon, silicon, silver, tin, lead, vanadium, chromium, molybdenum, tungsten, manganese, cobalt, and nickel.

Table XVI contains the nominal composition, tensile properties, and minimum bend radii of several of the best compositions in the form of 0.060-inch sheet. Since all of these were prepared from small ingots given relatively low degrees of reduction, it is probable that still better properties could be obtained from larger ingots.

WHERE DO WE STAND TODAY?

To put it briefly, designers and metallurgists are enthused about the possibilities of titanium. Its high cost still has to be overcome before it can be used in quantity in commercial applications, although insofar as military uses are concerned, cost may be secondary.

The refining and producing situation is beginning to shake down somewhat. Three concerns loom as large suppliers of titanium powder and sponge: duPont, National Lead, and New Jersey Zinc. DuPont, in the last year, supplied up to 90 percent of the titanium metal produced in this country in one form or another. But National Lead will come into the picture to a greater extent, especially if they have, as reported, developed a cheaper process for producing titanium tetrachloride. Exactly where New Jersey Zinc stands at the moment is not known, but they potentially are a large producer if for no other reason than their joint control of the Allard Lake ore deposits with Kennecott Copper.

In processing the metal from the sponge or sheet form, it is hard to see how the stainless steel manufacturers can be anything but major operators. As Allegheny-Ludlum says, "We simply send the material to one of our mills and tell them to work it at 400 to 500 F lower than they work stainless steel." In view of the fact that such steel producers have existing equipment already installed, and are experienced with alloy steel melting procedures and techniques, and must protect themselves to the extent that they can supply the metal in sheet and bar form if it takes over a goodly portion of the stainless steel market, they probably will jump into developmental work in the near future if they are not in already. There are persistent rumors in the industry that the Carpenter Steel Company is doing some research on titanium, although they deny it. Republic Steel is also said to be interested. Remington Arms, a subsidiary of duPont, may go to quantity production, although this would involve considerable capital expenditure.

As soon as quantity production starts, the patent situation will probably clear up. Everyone now is filing disclosures on alloys. Battelle Institute, P. R. Mallory, and other laboratories such as Armour who have contracts with government bureaus share proprietary patent rights in conjunction with the bureau involved. Battelle Institute already has filed a number of patent applications on alloys; P. R. Mallory is filing disclosures on their promising alloys; Allegheny-Ludlum is protecting themselves with a number of narrow compositions; and other concerns undoubtedly are doing the same.

What eventually may come out of the present confusion is a group of standard industry-wide alloys, such as the AISI standard stainless steels, plus a number of proprietary alloys. However, such standardization is several litigation suits and a few years away.

Perhaps the best way to summarize the present commercial status of titanium is to cite the status of one producer. The research laboratory of this concern is presently melting ingots up to 100 pounds in weight, and melting of ingots up to 500-

pounds in weight is planned. Present plans call for expanding this work according to market requirements and availability of titanium sponge for melting stock.

Since the fabrication of titanium is quite similar to that of stainless steel, the forging and rolling facilities in the various mills of the corporation are quite satisfactory for handling titanium. The present price for their titanium forgings is $10.00 per pound, and that for sheet is $20.00 per pound. These prices are based upon $5.00 per pound cost of sponge metal, and special handling of a very small production volume. The cost of melting and fabricating titanium may be expected to decrease with an increase in production volume and in approximate proportion to the decrease in the price of sponge metal.

A special type of arc furnace is used for melting titanium under inert gas atmosphere with little or no contamination of carbon, oxygen, or nitrogen. The tensile properties of unalloyed bar are dependent upon the quality of sponge metal available and average 70,000 to 80,000 psi tensile strength, with 28 to 30 percent elongation.

Considerable work is being done on small melts of titanium with various additions of nitrogen, carbon, oxygen, and metallic alloys. Alloys up to 230,000 psi tensile strength have been made and an alloy of approximately 150,000 psi and 15 percent elongation is now being produced for various experimental applications, principally aircraft engine parts.

No particular difficulties have been experienced in the hot working of bar, strip, wide sheet, or forgings. It is believed that structural shapes also may rolled without difficulty. Experimental work is underway, with various divisions of this company and with other companies, on the manufacture of wire, tubing, die forgings, and extrusions.

ACKNOWLEDGMENT–PRODUCT ENGINEERING thanks the following laboratories and concerns for the data and assistance they supplied during the preparation of this article:

Department of Defense
Naval Bureau of Aeronautics
Wright-Patterson Air Force Base
Office of Public Information
U. S. Bureau of Mines
Titanium Alloy Manufacturing Company, Division of National Lead
Battelle Memorial Institute
P. R. Mallory & Company, Inc.
Allegheny-Ludlum Steel Corporation
Westinghouse Electric Corporation
Remington Arms Company, Inc.
E. I. DuPont de Nemours & Company, Incorporated

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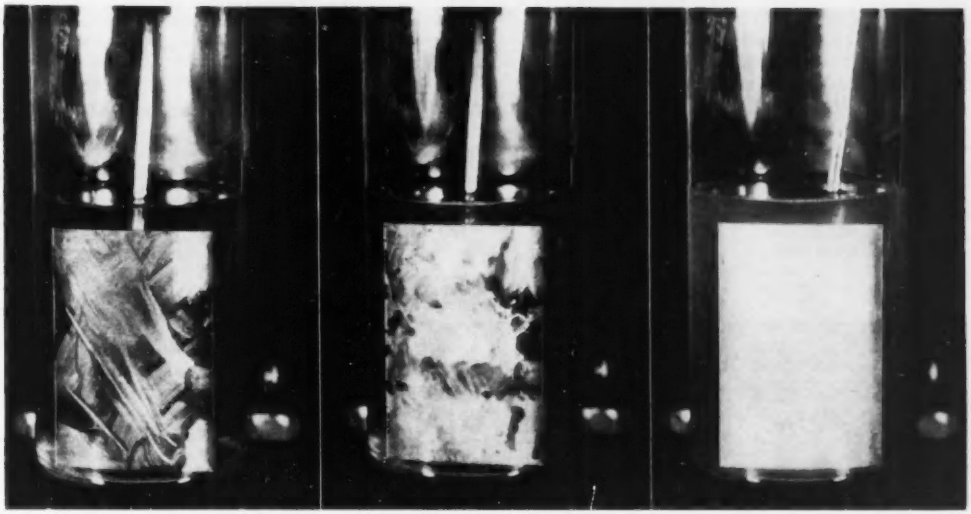
TECHNICAL NEWS



DEGREASING OF STEEL PLATE becomes a matter of seconds when caustic solution surrounding plate is agitated by 30,000-cps sound wave. Bouncing of liquid's molecules on steel produces forces several thousand times the force of gravity.

Ultrasonics Has Wide Industrial Applications

ACCORDING TO EXTENSIVE TESTS conducted at the Massa Laboratories, Cleveland, Ohio, ultrasonics will be put to many practical uses in widely diversified industrial fields. Engineers of American Steel and Wire Company and Ferro Enamel Corporation witnessed a demonstration of sound wave application in their field—degreasing of sheet steel and small stampings.

High frequency sound waves were used to agitate a caustic solution surrounding heavily greased parts. Bouncing of the solution's molecules against the coated surfaces resulted in a dramatic scrubbing action. Normally, a 20-min job for standard equipment, degreasing by the ultrasonic process took just 10 sec. Aside from the rapidity of the degreasing action were the advantages that the solution was at room temperature and no acrid fumes were present.

The engineering principles used by Frank Massa, head of the Laboratories, are those applied during the recent war to detect enemy submarines. The two basic facts responsible for the industrial role of high frequency high intensity sound are:

(1) Sound vibrations can be generated with such magnitude in liquids that molecules can be bounced around to produce forces equal to several thousand times the force of gravity.

(2) The forces can be produced in the liquid in fractions of a second; they can be generated by several practical methods that lend themselves to use in production machinery.

In the cleaning operation, a magneto-strictive transducer was used. This alloy of nickel and cobalt was made to oscillate at a rate of 33,000 cps by a high-frequency electric current. For frequencies above 100,000 cps, the piezo-electric crystal is the device generally utilized.

Degreasing steel is only one of the applications of sound in industry. It can mix incompatible liquids like oil and water, mercury and water; can disperse particles through liquids to make synthetic colloids.

Sound may produce new alloys through its power to combine metals of different melting points, iron and copper, for instance. In a molten mixture of iron and copper, the copper tries to separate out during cooling. But if ultrasonic waves are introduced during cooling, the molecules of copper will arrange themselves evenly throughout the mass. Result—an iron-copper alloy.

Castings can be degassed by subjecting the molten liquid to sound bouncing during the cooling period.

Fine fogs or mists can be produced by concentrating sound energy at a point near the surface of the liquid. In the printing industry, the fog could be used to form a fine, uniform layer of ink on rolls or printing plates.

Sound treatment can increase the wetting action of a liquid. That can help the textile people.

Still in the "maybe" stage is the idea of dispersing fibers throughout a liquid. Sound waves might cause the fibers to align in a particular direction. The paper and felting industries stand to gain most if this theory proves successful.

Sound waves are under study as a means of producing new types of carburetion by vaporizing nonvolatile fuels. This could be of great importance to internal-combustion engine makers.

Other uses for sound include an electrolytic process to tin aluminum wire, precipitation of acid mists in in-

dustrial plants, paper drying (sound waves shake the sheets dry), and aging liquors. Some of the more enthusiastic sound men believe that sound can even kill bacteria.

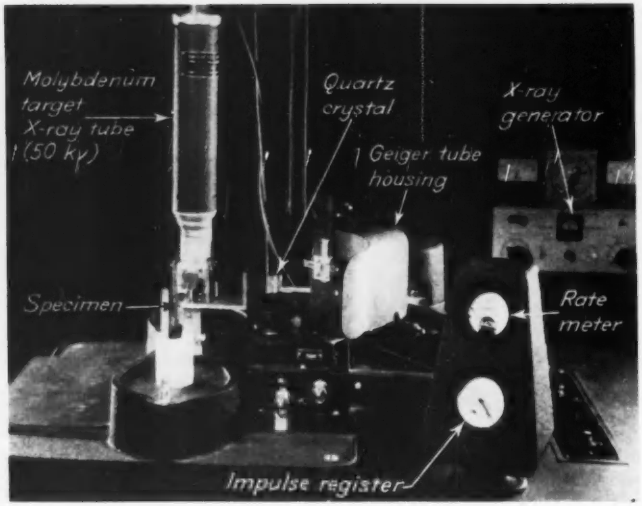
Ultrasonics ranks high on the list of research projects at many laboratories. Battelle Memorial Institute, Columbus, Ohio, has made advances during the past year in using ultrasonics to test the depth, and angle of flaws in steel tubes and parts. Battelle has also used ultrasonic measurements to determine the elasticity of aircraft steels. Ultrasonics has also measured the thickness of parts from one side only—for example, the wall thickness in a closed vessel.

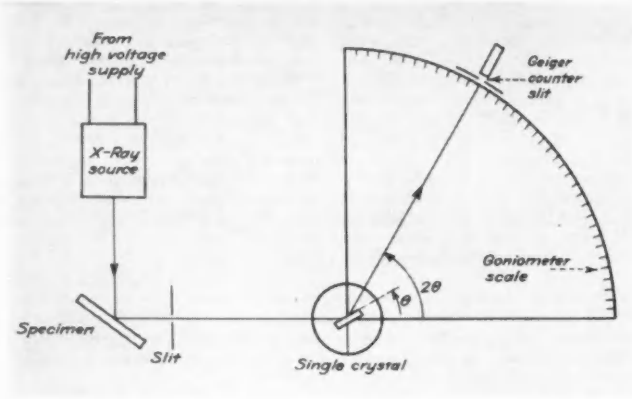
Extremely hard, fine particles of ceramic materials have been broken up into sizes that pass readily through a 200-mesh screen. Ultrasonic power for noiseless drilling of hard ceramics and metals has also been studied.

Geiger Counter Speeds Analysis of Alloy Steels

THE GEIGER COUNTER, widely known for its ability to detect uranium and other radio-active minerals, has been adapted by researchers of United States Steel Corporation to the development of a quick and accurate method of analyzing steel samples.

After careful calibration for many specific problems, many of which are yet to be solved, Geiger-counter analysis of steels is expected to be much faster than the direct-reading spectograph, which itself is a recent development in metallurgical analysis. The counter is used in conjunction with special spectrograph equipment and is said to have achieved extraordinary results in revealing quickly the kind and quantity of alloying elements in steel specimens.





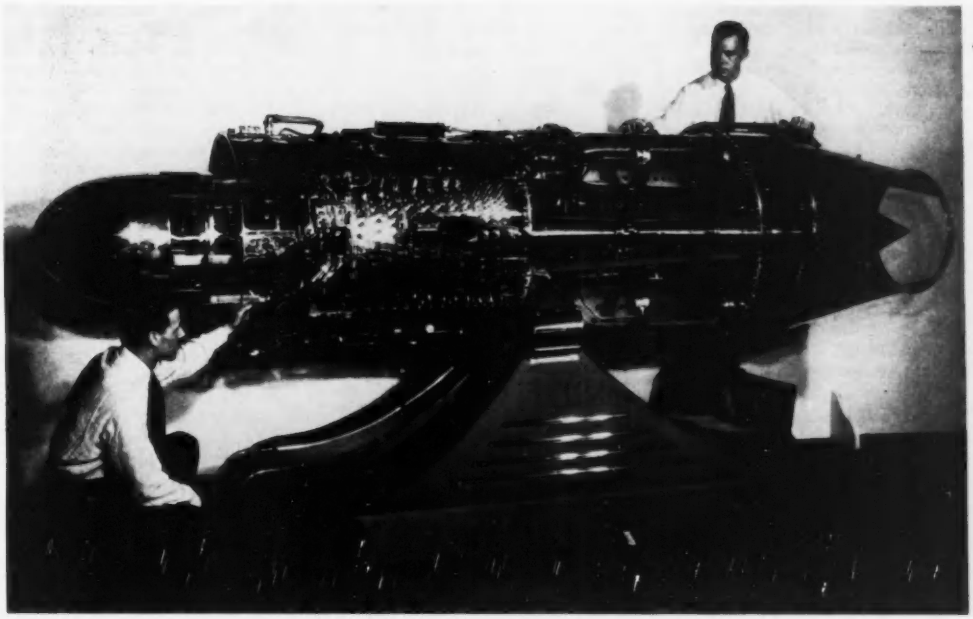
FLUORESCENT RAYS reflected from steel specimen have characteristic intensities that indicate presence of various alloy elements in specific quantities.

This does not mean that the chemical elements combined in the steel are radioactive, as might be inferred from the fact that the Geiger counter has been publicized as an aid to nuclear scientists. As it is capable of detecting and measuring radioactivity, the instrument is capable also of measuring invisible fluorescent rays, each of a special kind, that emanate from a steel sample when its particles are ionized by powerful X-rays. The sample's iron atoms and the atoms of alloying elements are in no way harmed or changed by the new analysis method.

Dr. James B. Austin, director of research for U. S. Steel, pointed out that it has been known for many years that chemical analysis of metals is possible from fluorescent or secondary X-rays. But progress in the field has been handicapped by lack of intense X-ray sources and the necessity in the past of measuring the intensities of the rays by blackening a photographic film.

In the U. S. Steel laboratory studies (see illustration), a 20-milliamp 50 kw molybdenum target X-ray tube is used. The ray floods the steel specimen, exciting secondary rays that are characteristic of the chemical elements alloyed with iron in the sample. These fluorescent rays are reflected through a narrow slit at right angles to the path of the primary X-ray to a crystal monochromator. This crystal is in the center of a circle, one-fourth of whose circumference is traversed by a Geiger counter in its round of analysis.

The new method of analysis is best adapted to detect and measure elements of "middle" atomic weight (22 to 50). Among these are elements most often combined with iron and carbon forming the various steels in common use.



AIR FORCE OFFICIALS have partially removed the cloak of secrecy from General Electric's J-47 Turbojet engine. Operating details of the largest American mass-produced powerplant were demonstrated during the recent National Air Races in Cleveland, Ohio. Among the operating parts shown publicly for the first time is the water injection system that boosts the J-47's basic thrust of 5,200 lb during takeoff periods. The engine burns either kerosene or grade 100/130 gasoline in the seven combustion chambers, while consuming 90 lb of air every second in the twelve-stage compressor. Unit is lubricated through a pressure feed and return oil system to bearings and accessory gears, and its electrical system comprises a direct drive starter-generator. Two igniter plugs and two 400-cycle ignition transformers are sufficient for firing all the burners.

Washington Notes

New ECA Purchase Program To Help Small Business

Administrator Paul G. Hoffman has announced details of the Economic Cooperation Administration's program to provide American small business firms with greater opportunities to share in Marshall Plan business.

Announcement of the program came after several months' study to develop methods for meeting a Congressional directive that called for furnishing to small business information regarding proposed ECA-financed purchases. The program is designed to give small independent firms a greater chance to supply goods for European recovery.

When in full operation, the program will provide: (1) A counseling service in exporting under the Marshall Plan; (2) information of potential purchases to be made in the United States; (3) names and addresses of European importers and the products they have purchased under the Marshall Plan; (4) information regarding commodities that offer the greatest opportunities for sales in Western Europe; and (5) a directory listing names and addresses of potential American exporters, by commodities. This directory will be for overseas distribution and will be available through ECA overseas missions to European importers seeking additional American sources of supply.

Improved Fuels for Rockets Developed at NACA

Better fuels for rocket and jet engines are promised for the near future as a result of research at the Lewis Flight Propulsion Laboratory of the National Advisory Committee for Aeronautics. Equally important are experimental engines capable of delivering the extremely large powers required for supersonic speeds.

All sorts of fuels and fuel combinations are being tried. Some have been found that, experimentally, give far better results than those now in general use. One studied is 2.5 times as powerful. Particularly important is the research work to develop better jet engines able to withstand the very high temperatures at which they operate, and to construct them of materials available in the United States or in the Western Hemisphere.

With the increasing use of rockets and ram-jet engines to give combat planes greatly increased power for short periods in emergencies, fuels that will ignite at the extremely low temperatures encountered at high altitudes are essential. Also essential are fuels whose flames will not blow out in the speeding ram-jet.

Rocket fuels, which at low altitudes and moderate temperatures ignite spontaneously and rapidly upon contact, may refuse to ignite at high altitudes, or they may ignite in explosive fashion, destroying the rocket engine. Two solutions are being worked out at the Lewis Laboratory. One is to keep the engines and the fuels sufficiently warm to insure prompt and

safe starting. The other is the use of added substances to the fuel to shorten the ignition lag.

Because the air in a ram-jet passes through the combustion chamber at high speed, there is a tendency for the flame to blow out. Operating the engines at high altitudes with resulting low pressures also makes combustion difficult. Since 1945, the velocities at which good combustion efficiencies can be maintained have been increased three-fold, and further progress is expected. Similar progress has been made in increasing the altitude limits for satisfactory combustion, a result of intensive research on flame-holding devices, fuel-injection methods and combustion chamber design.

Supersonic Wind Tunnel Completed at Langley Field

Details of a new giant wind tunnel for studying supersonic flight have been released by the National Advisory Committee for Aeronautics. The "secret" 4- by 4-ft tunnel has been in preliminary operation at Langley Field, Virginia, for the past year.

The tunnel can be completely sealed to facilitate operation at pressures from 0.25 to 2.5 times atmospheric pressure, thus providing for a wide range of Reynolds numbers. Gates permit isolation of the test section so that model changes can be made without the necessity of returning the entire tunnel to atmospheric pressure.

The Mach number of the tunnel can be varied from 1.2 to 2.2 through the use of a flexible wall nozzle ahead of the test section. In a subsonic tunnel, the maximum velocity occurs at the section of minimum area and the speed can be increased simply by increasing the tunnel fan speed. In a supersonic tunnel, the maximum velocity is attained in a region of expanded area downstream of the minimum section and the velocity can be raised only by increasing the ratio of the area of the expanded section to the area of the throat section. This area ratio is varied in the tunnel by adjusting the flexible walls of the nozzle. These 25-ft wall sections are actuated by a series of jacks that maintain the nozzle contour to an accuracy of 0.005 inch.

Drying and cooling equipment in the tunnel permits the reduction of moisture content of the air to as low as one part of water in 10,000 parts of air and lowering of stagnation temperature from 250 F to 110 Fahrenheit.

With this new facility, it is possible to utilize test models large enough to permit installation of extensive instrumentation. During the past year, a complete supersonic airplane of 32-in. wing-span has been under investigation. This model is fitted with movable controls and more than 300 pressure orifices. The results obtained provide detailed information on viscous and interference effects unobtainable in smaller supersonic tunnels. An investigation concerning the phenomenon of shock-wave detachment at the leading edge of supersonic wings is also being conducted.

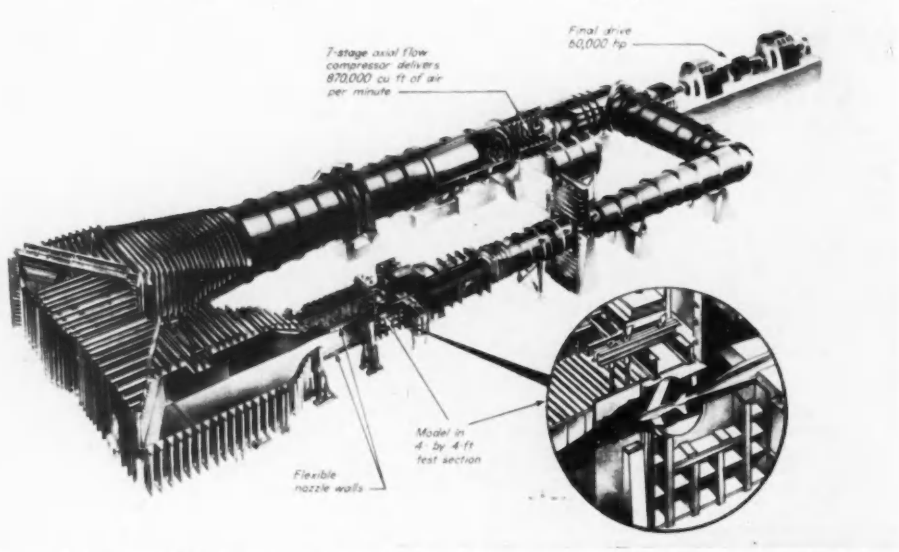
Munitions Board Establishes Information Center

Opening of a Military Procurement Information Office to provide a central directing service to businessmen seeking contracts with the military services has been announced by the Munitions Board.

In its announcement, the Munitions Board pointed out that the center, located at the Pentagon Building in Washington, will be of primary value to concerns who are not accustomed to doing business with the armed services.

Embrittlement Tests Developed in ONR Studies

During the past ten years, researchers have become aware that small quantities of an impurity or undesirable constituent can exert an exceedingly large effect upon the behavior of a metal in service. In fact, small quantities have been sufficiently influential so that it has become necessary to develop methods of analysis


Final drive
60,000 hp
7-stage axial flow compressor delivers 870,000 cu ft of air per minute
Model in 4- by 4-ft test section
Flexible nozzle walls

ARTIST'S SKETCH of NACA's 4- by 4-ft supersonic wind tunnel. Compressor rotor weighs 70 tons, carries 1,137 blades.

that will detect the presence of even the most minute traces.

The Office of Naval Research has sponsored two research projects at the Massachusetts Institute of Technology. One project deals with the detection of hydrogen in metals; the other with the measurement of austenite in steel.

It has long been known that hydrogen causes steels and other metals to become embrittled. But an exact evaluation of its effect could not be obtained because of the long, tedious methods necessary for analysis. Furthermore, during the production of a steel, it is not sufficient merely to know how much hydrogen *was* present. It is necessary to have these data at a time when corrections can be made.

According to Dr. Irving Kramer, head of the ONR Materials Branch, the work at M.I.T. has resulted in a method that permits the determination of hydrogen content in 15 minutes. This method not only affords accurate and reproducible results, but also allows steel mill metallurgists to keep tabs on various steel melts. This method of analysis has already been put to work and valuable information concerning the "pick up" of hydrogen in steel has been obtained.

The presence of austenite in steels having a carbon content above 0.7 percent is well known, Dr. Kramer stated. In these steels, austenite markedly influences the properties so that special heat treatments are necessary. In addition to lowering the hardness, the austenite is unstable at room temperature, with the result that the dimensions of a die or gage block sometimes change as the austenite decomposes either on standing or upon being subjected to low temperatures.

Drs. B. L. Averback and N. Cohen of M.I.T. have recently developed a method that will detect austenite in plain carbon steel containing as little as 0.1 percent carbon. Since these low carbon steels are often used for structural purposes, the presence of austenite becomes an extremely important factor. If present, this austenite can decompose under the action of a plastic strain to form a hard constituent that makes steel brittle. This consideration becomes important when steels are heat treated to a high hardness or are used in an untempered condition such as in weldments. Even when the steels are tempered so that the austenite contained after quenching is transformed, the resulting constituent can produce a steel that is less ductile than a steel that is heat treated to get rid of the austenite.

QUALITY CERTIFICATION SEAL

LICENSEE INSIGNIA

CERTIFICATION SEAL identifies zinc die castings conforming to ASTM fabrication standards. Licensee insignia symbolizes integrity of casting producer.

Certified Zinc Alloy Plan Adopted by Die Casters

ADOPTION OF THE CERTIFIED ZINC ALLOY PLAN by the American Die Casting Institute is considered the biggest forward step ever taken by the rapidly-growing industry. This action was taken at the recent Annual Meeting of the Institute whose members represent about 75 percent of American zinc die casting tonnage.

Definite and proper composition limits for zinc die casting alloys have long been established by the American Society for Testing Materials, and it is the purpose of the new plan to insure that every zinc die casting bearing the Certification Seal shown will be produced from metal conforming to these limits. This quality control is accomplished under the plan by frequent sampling of castings from all participating die casting producers for analysis by an approved laboratory.

Producers subscribing to this plan may now identify all their zinc die castings with the Certification Seal. This mark of assured quality, therefore, identifies member producers and serves to assure the die casting purchaser that his parts have been produced from proper zinc alloys.

Chemical Element Names Revised by World Group

THE SYMBOL "W", denoting tungsten, takes on a real meaning now that the official name of the element has been changed to wolfram. This is one of six changes from American usage in element names that were adopted at the 15th International Union of Chemistry held this September at Amsterdam and recently reported to the American Chemical Society.

Columbium was discarded in favor of niobium and beryllium made official instead of glucinium. Hafnium was approved without change, while lutecium and proto-actinium were modified to lutetium and protactinium, respectively.

Two elements discovered in atomic fission products had their names respelled: Technitium for element 43 and promethium for element 61, both of which previously ended in "eum."

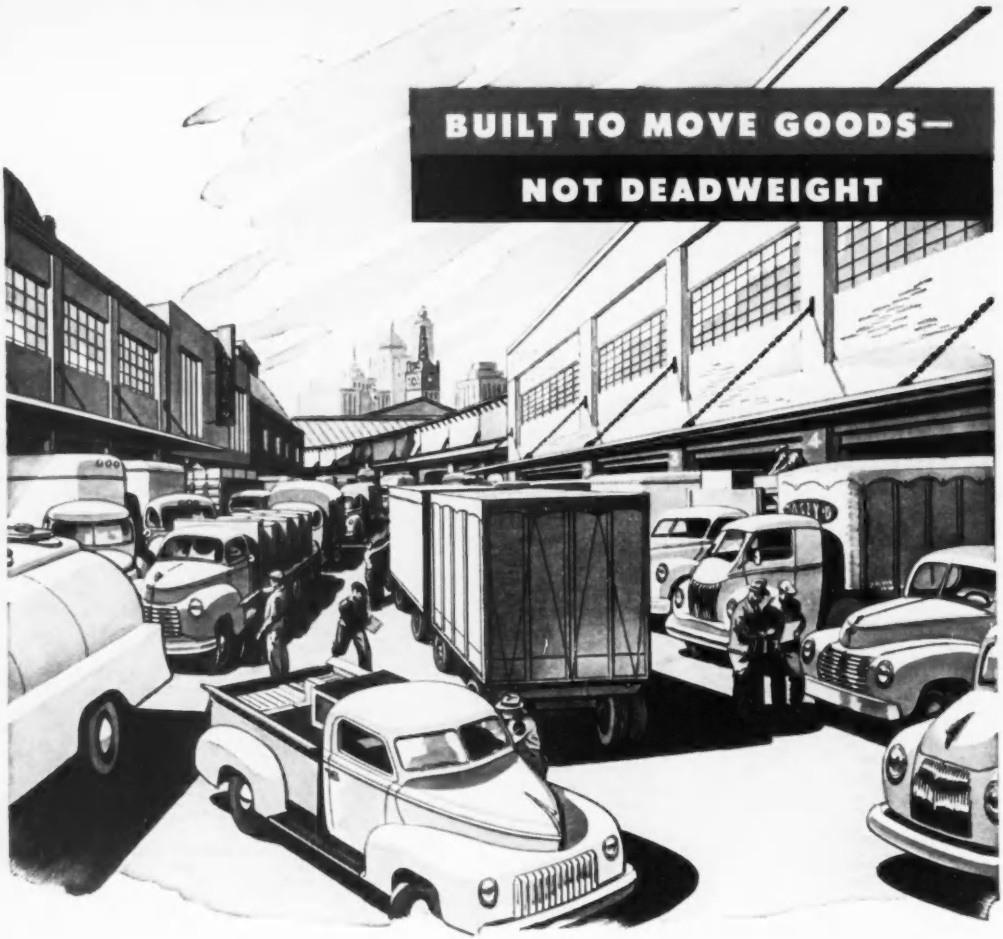
Six other elements discovered during atomic bomb research had the names given them by their American discovers made official internationally: Astatine for 85, francium for 87, neptunium for 93, plutonium for 94, americium for 95 and curium for element ninety six.

Actuator Developed To Prevent "Jams"

DETAILS of a non-jamming electric actuator, designed to insure non-failing and instant operation of critical control surfaces on high-speed aircraft, have been disclosed by AiResearch Manufacturing Company, Los Angeles, California.

The new device, called a torsional-friction, non-jamming, positive-stop actuator, is stated to differ from other actuators in that it utilizes a torque bar inside the jack screw.

This bar is intended to absorb the jam shock at the end of the actuator stroke and store up energy like a spring for the return stroke.



The weight's in the load and not in the truck when frames, body panels, fenders, wheels and other truck structural parts are made of N-A-X HIGH-TENSILE. And while affording weight savings of up to 25% in section, the high physical properties of N-A-X HIGH-TENSILE insure superior strength and increased resistance to fatigue, corrosion, abrasion and denting.

This decrease in deadweight decreases on-the-job expenses, too. Trucks built with N-A-X HIGH-TENSILE consume less gasoline . . . require less maintenance . . . give longer service. And the excellent formability, weldability, and fine surface texture of N-A-X HIGH-TENSILE mean that you build them better, with no added fabricating problems.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N·A·X
HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

Helical Gear Nomograph

WAYNE A. RING
Barber-Colman Company

Let:

C = exact center distance, in.
N = number of gear teeth
n = number of pinion teeth
α = helix angle, radians
P_n = normal diametral pitch, in.

Then:

$$C = \left(\frac{N+n}{2}\right)\left(\frac{1}{P_n}\right)\left(\frac{1}{\cos\alpha}\right)$$

To solve:

Connect P_n with C; connect $\frac{N+n}{2}$ and α with parallel line. Chart is useful in finding combinations of α and P_n for given C and $\frac{N+n}{2}$ etc.

Example:

$C = 3$ in., $P_n = 12$
$N = 35$, $n = 25$ $\Big\}$ $\frac{N+n}{2} = 30$

$$\cos\alpha = \frac{30}{12 \times 3} = 0.833$$

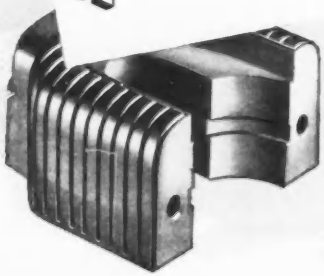
α = 33 deg 33 min

TUNE IN "SUSPENSE"
CBS RADIO NETWORK THURSDAYS
CBS TELEVISION TUESDAYS

AUTO-LITE

DIE CASTINGS

● Increased production facilities for die castings made possible through the famous Auto-Lite "controlled metals" processes are now available. The opening of the great new Lockland plant of Auto-Lite, combined with the enlarged facilities at Woodstock, Illinois, greatly increases Auto-Lite's ability to furnish high quality die castings.



THE ELECTRIC AUTO-LITE COMPANY
Die Casting Division, Woodstock, Illinois

600 S. Michigan Ave.
Chicago 5, Illinois

723 New Center Bldg.
Detroit 2, Michigan

Inquiries invited

Catalog will be sent on request.
Write on your company letterhead.

Belleville Spring Design Charts—VII

LESLIE W. JONES
Corning Glass Works

For description of chart construction see Product Engineering, January 1949, page 161.

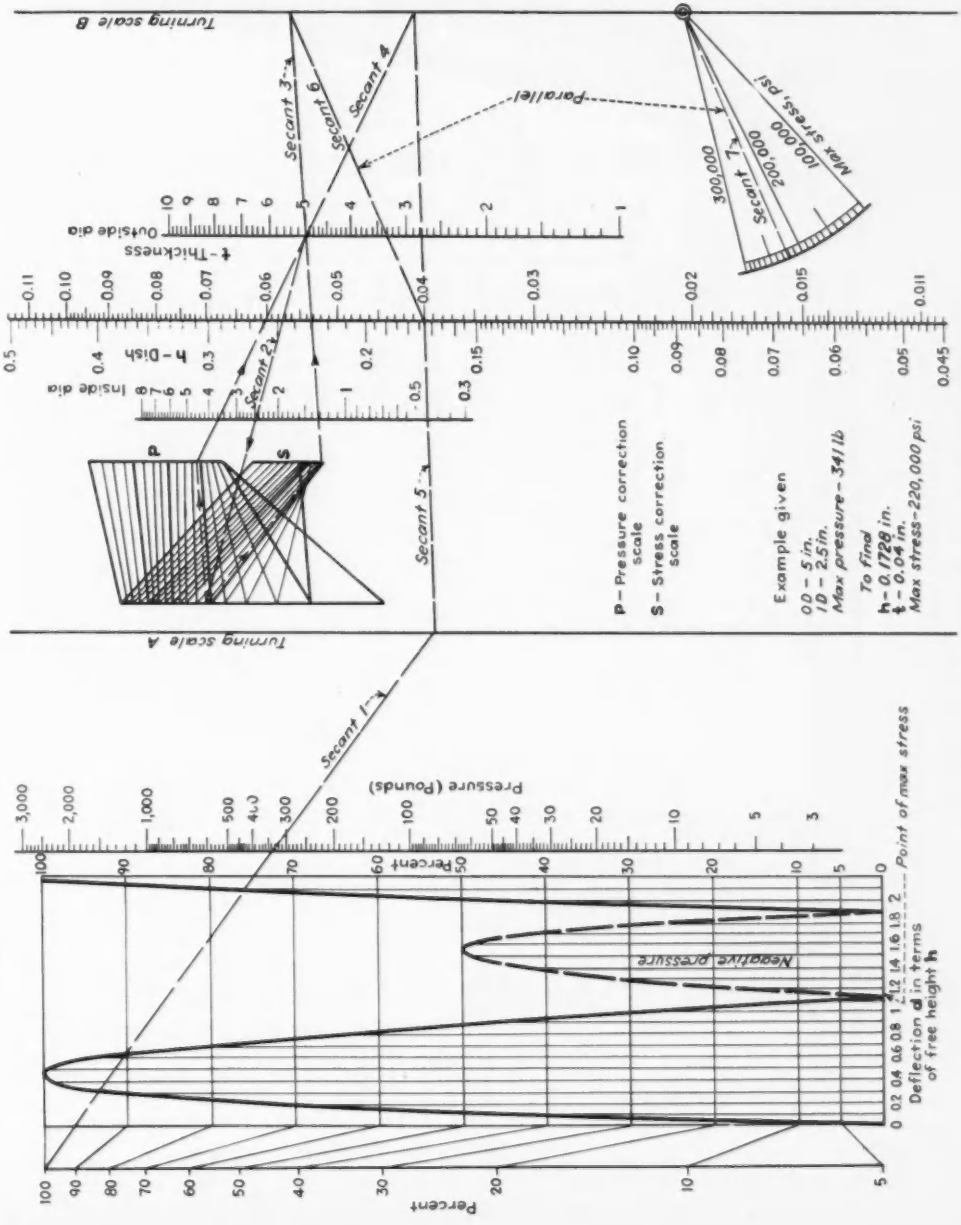
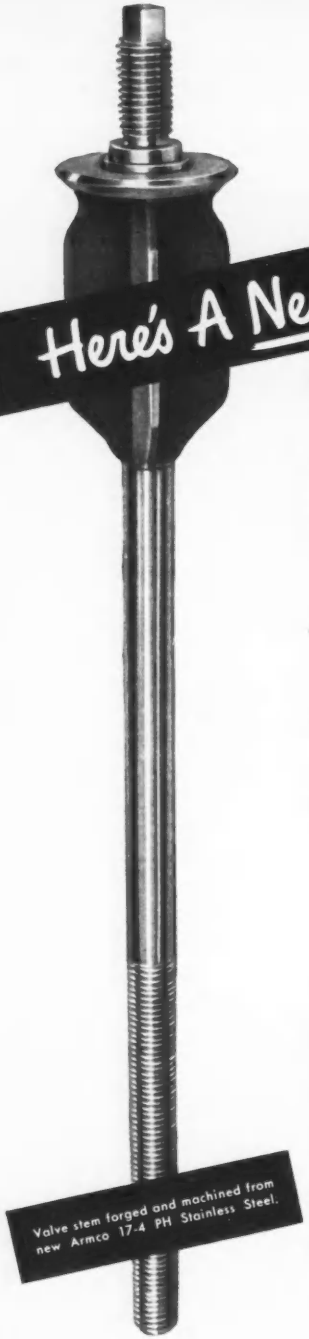

Turning scale B
Secant 3
Secant 6
Secant 4
Parallel
Max stress, psi
100,000
200,000
300,000
Secant 7
t - Thickness
Outside dia
0.11 0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.03 0.02 0.015 0.011
h - Disk
Inside dia
0.5 0.4 0.3 0.2 0.15 0.10 0.09 0.08 0.07 0.06 0.05 0.045
Secant 2
Secant 5
P
S
P - Pressure correction scale
S - Stress correction scale
Example given
OD - 5 in.
ID - 2.5 in.
Max pressure - 341 lb
To find
h - 0.1728 in.
t - 0.04 in.
Max stress - 220,000 psi
Turning scale A
Secant 1
Pressure (Pounds)
3,000 2,000 1,000 500 400 300 200 100 50 40 30 20 10 5 3
Percent
100 90 80 70 60 50 40 30 20 10 5 0
Negative pressure
Point of max stress
Deflection d in terms of free height h
0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2
Percent
100 90 80 70 60 50 40 30 20 10 5

CHART FOR FIFTY PERCENT NEGATIVE PRESSURE



Valve stem forged and machined from new Armco 17-4 PH Stainless Steel.

Here's A New Stainless Bar Grade

WITH 8 UNUSUAL ADVANTAGES

If your products require extra strength and hardness *combined with excellent corrosion resistance*, you'll be interested in the revolutionary new properties of Armco 17-4 PH Stainless Steel bars and wire.

This new precipitation hardening grade, a development of Armco Research, offers you an exceptional combination of 8 advantages:

1. It is hardenable by heat treatment to Rockwell C-40/45.
2. This hardness is obtained by heat treating in the low range of 850-900° F. for one hour, and air cooling.
3. Only a superficial, easy-to-remove heat tint results from the heating operation. This means that close tolerance parts can be finish-machined before hardening—eliminating finish machining or grinding after hardening.
4. Because of low hardening temperatures, distortion is virtually eliminated.
5. Freedom from hardening cracks.
6. Stress relieving treatment is not needed with Armco 17-4 PH Stainless Steel.
7. Machinability is good (between Types 302 and 303) in the annealed condition; fair when the steel is fully hardened. It can be readily hot worked and has good welding properties.
8. Its corrosion resistance is close to that of Types 302, 303, and 304.

Armco 17-4 PH may be just the stainless steel you need for better product performance or to solve special fabricating problems. For complete information, just fill in and mail the handy coupon. Armco Steel Corporation, 4169 Curtis Street, Middletown, Ohio.

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MAIL TODAY FOR MORE DATA

Armco Steel Corporation, 4169 Curtis Street, Middletown, Ohio

Send me complete information on Armco 17-4 PH.

NAME_____ TITLE_____

FIRM NAME_____

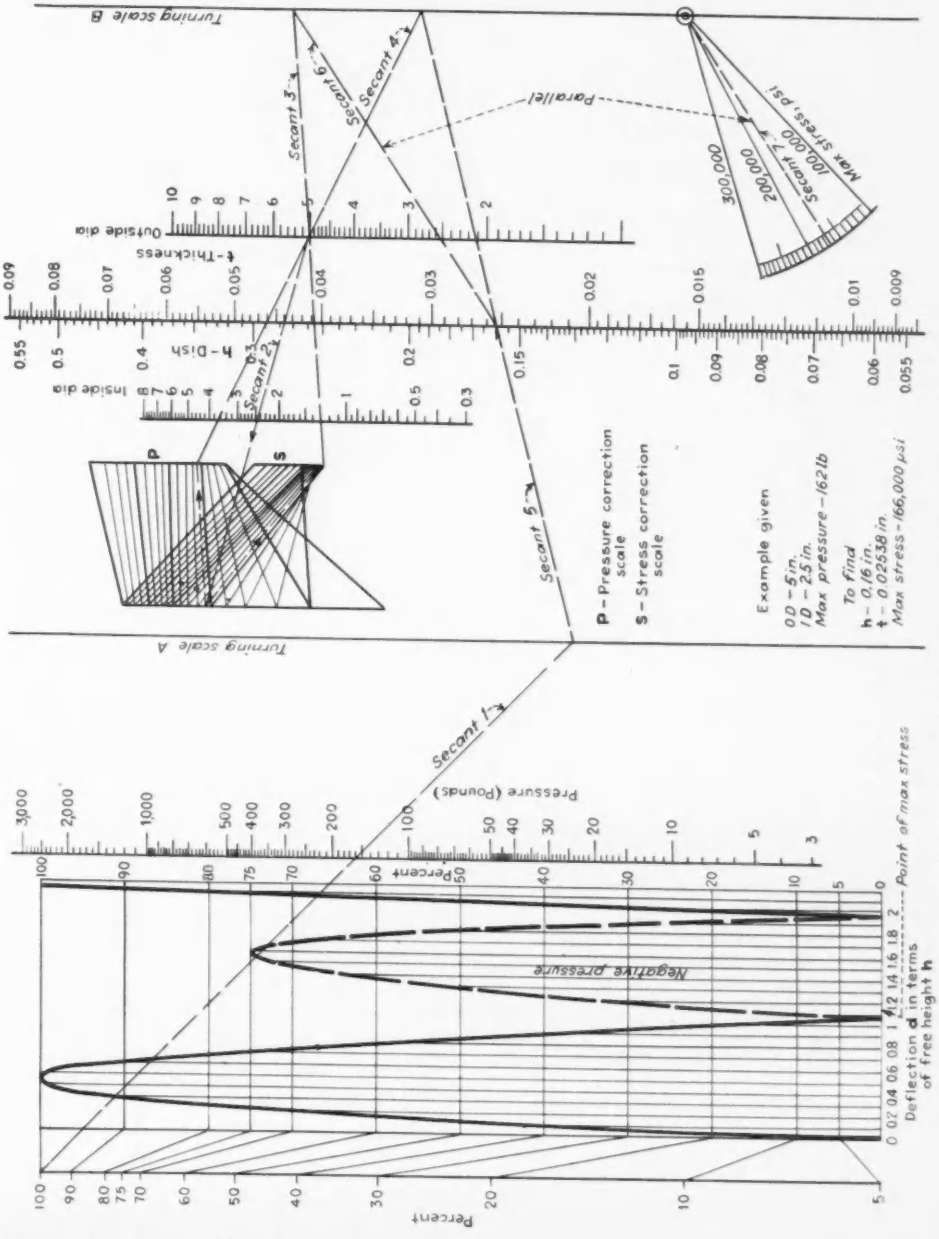
STREET_____

CITY_____ ZONE_____ STATE_____

ARMCO STEEL CORPORATION

ARMCO

Belleville Spring Design (continued)



Unit-Type Construction Featured in New Pillow Block

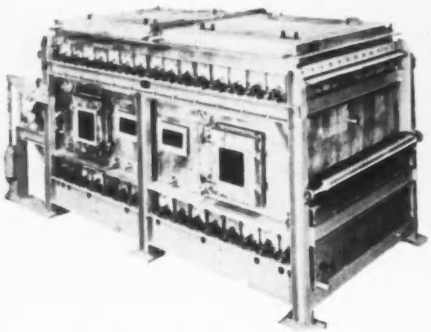
It can be mounted as a unit with a press-fit on shaft without exposing bearing surfaces.

This completely assembled, lubricated unit can be slipped on a shaft and quickly locked into place by turning one tightening nut with a spanner wrench. The nut forces a tapered split sleeve to wrap around the shaft and give a press-fit without burring the shaft. Disassembly is just as easy—the tightening nut is backed off, and the removal nut on the opposite side is tightened.

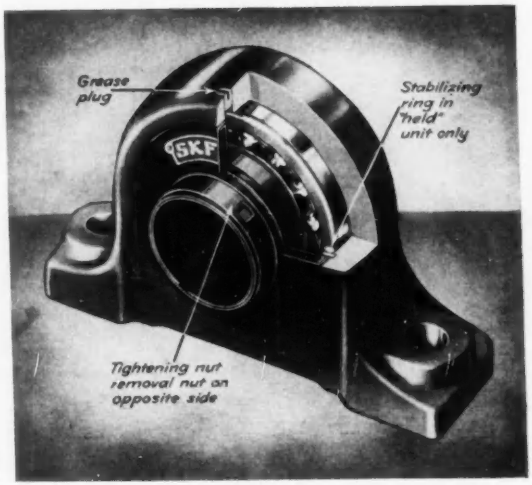
These bearings are furnished in either the "free" or "held" types. In the "held" type the bearing is located centrally in the housing and held there by spacer rings. The "free" type does not have the spacer or stabilizer rings and the bearing is free to move axially in its housing. It is common practice to have one "held" unit on each shaft in order to limit axial movement of the shaft. Other units on the same shaft should be of the "free" type in order to permit shaft expansion caused by temperature changes.

Pillow blocks are available with shaft sizes from $1\frac{7}{16}$ to $2\frac{7}{16}$ inches. The weights vary from $4\frac{3}{4}$ to $11\frac{3}{4}$ pounds. The buyer should specify either the "free" or "held" type when ordering.

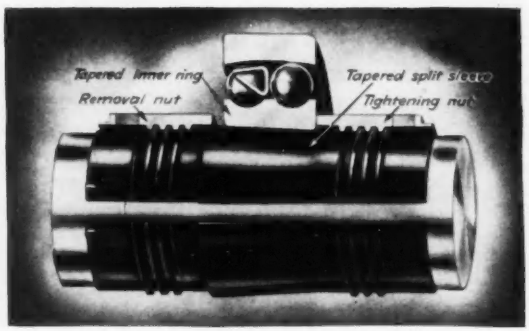
SKF Industries, Inc., Philadelphia 32, Pa.



SIXTY-FOUR SKF unit-type pillow blocks are used on this cloth steamer.



COMPLETELY ASSEMBLED, lubricated, and ready for operation, these unit-type pillow blocks have self-aligning ball bearings, they automatically compensate for misalignment and handle shaft deflection without binding, thus insuring equal load distribution at all times. The labyrinth seals permit a generous supply of lubricant without causing internal pressures which tend to tighten bearings.



TIGHTENING NUT forces the tapered inner ring up on the tapered split sleeve and the sleeve wraps around the shaft to form a press-fit. The large lead angle of the threads makes it difficult to force the nut on too tightly. This would expand the tapered inner ring and tend to "freeze" the bearing. Both the tightening and removal nuts can be locked into place when tight by simply peening the thin extended lip of the nut into the adapter sleeve slot.

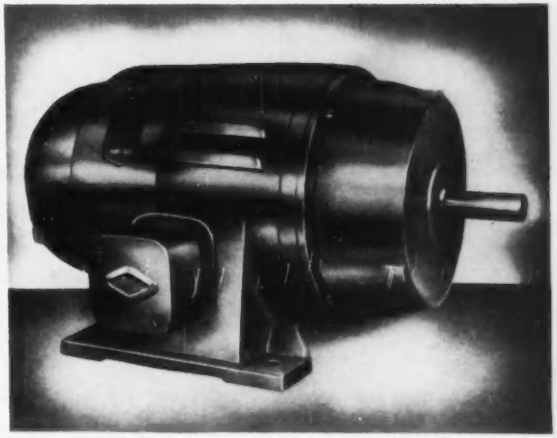
Motor Combined with Fluid Drive Coupling Gives Smooth Acceleration and Power Saving

The compact, integral designed fluid drive coupling and electric motor fit into conventional frame and end bells.

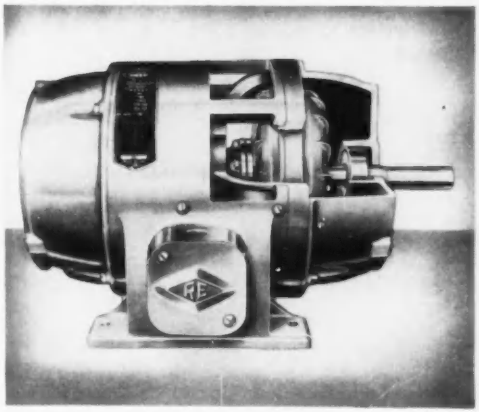
Combining the operational advantages of a fluid drive coupling with economical and space saving unit assembly, the "Fluid-Shaft" motor can be used in any operation where jamming or shock loading is expected. Conveyors, extractors, bridge and trolley drives on cranes, and winder operations are typical application examples.

There is no need to overmotor when selecting Fluid-Shaft units. Loads that are hard to bring up to speed with an ordinary motor are easily accelerated since the fluid coupling allows the motor to go practically up to speed before any load is applied. This allows the use of a smaller motor than would normally be required. For the same reason, the extremely high amount of current usually required to start and accelerate a motor under load is considerably reduced.

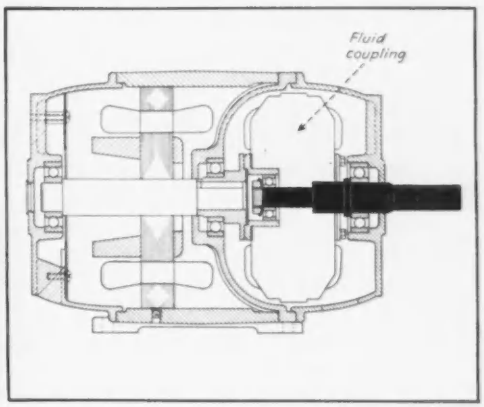
Reuland Electric Co., Alhambra, Calif.



USING STANDARD foot mounted or round body frames, this compact Fluid-Shaft motor can be mounted horizontally or vertically, or with NEMA flange and face type end bells. There are no special engineering problems in installation.



FLUID COUPLING and motor fit into standard Reuland frames. This eliminates the need for costly special housings. Units are available in ½, ¾, 1, 1½, 2, 3, 5, 7½ and 10 hp sizes.



OUTPUT SHAFT extends through the fluid coupling to a bearing on the motor shaft extension. This construction allows correct bearing spacing without extending length of the unit.

CONTINUED ON PAGE 166

Reeves Variable Speed Control Has Been Redesigned

Pressed steel and bronze replace cast iron to give more efficient, less expensive unit.

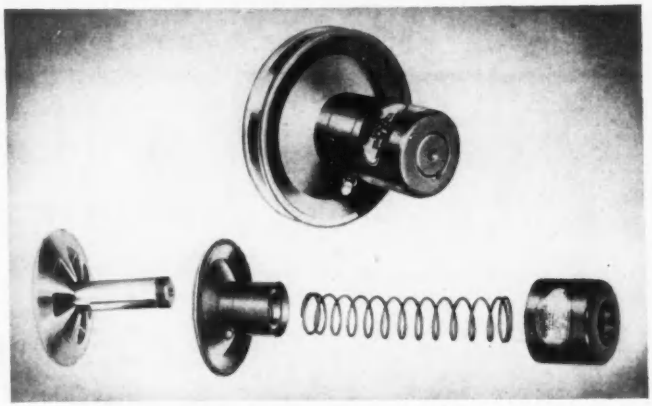
Made in six sizes for use with any standard constant speed motor up to 1½ hp., the Reeves Vari-Speed Jr. delivers infinitely variable speed to the driven machine between the range of 1.75 to 2.75:1. For examples of speed ranges for various models see the complete table on this page.

The unit consists of a self-adjusting V-type pulley which may be mounted on the shaft of a constant speed motor and connected by a V-belt to the driven machine. Moving the motor back on its sliding base causes the V-belt to ride on a smaller diameter in the expanding pulley, and the speed is decreased. Moving the motor in the opposite direction caused an increase in speed.

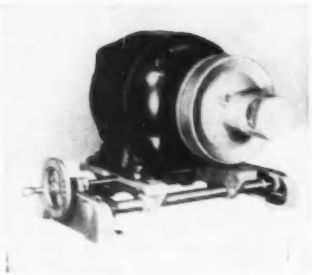
Since the redesign, fabricated steel replaces cast iron to allow closer tolerances, increased belt life, and a cheaper unit. Both cone-shaped disks are stamped from the same die to assure that the "fingers" or flutes will mesh perfectly. Also, when stamping these parts it was possible to round the corners of the flutes to assure a smooth surface for the belt at minimum speed positions.

A bronze hub on the sliding disk replaces cast iron to give a better bearing surface. A spiral lubrication system in the center of the hub distributes grease over the entire bearing surface.

Reeves Pulley Co., Inc., Columbus, Ind.



FOUR BASIC PARTS of the Vari-Speed Jr. are, from left to right: stationary disk, sliding disk, tension spring, and spring cover. The assembled unit is shown above. A Complete Variable speed unit, including a sliding base, is illustrated below.



VARI-SPEED JR. may be used with either a standard sliding base, as illustrated, or a pivoting type of base. Handwheel controls speed output of unit.

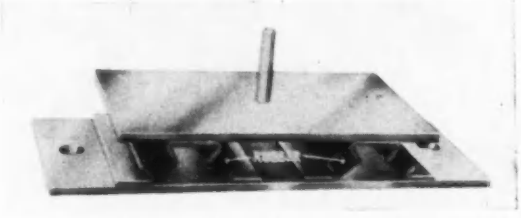
Pulley Size	830	840	850	860	870	875
Ratio	1.75:1	1.75:1	2.25:1	2.75:1	2.5:1	2.5:1
Min. Pulley	3	4	5	6	7	7½
R.P.M.	1160	1160	1160	1160	1160	1160
Hp.	½	½	½	½	¾	1
R.P.M.	1750	1750	1750	1750	1750	1750
Hp.	½	½	½	¾	1	1½
Min. Pitch Dia.	1.925	2.140	2.110	2.090	2.650	2.850
Max. Pitch Dia.	3.375	3.750	4.750	5.750	6.625	7.125
Motor Travel	1½	1½	3½	3½	3½	3½

Unitized Mounting Isolates Machine Vibrations Without Resonance

Working on the "rubber-in-shear" principle, this vibration mounting is for use with precision grinders, lathes, pumps, compressors, and other machines producing objectionable vibration or noise.

Specially designed steel channels are floated in rubber between steel angles. Because of the shear loading of the rubber, its spring index (load divided by deflection) is non-linear. For this reason the mounting has no constant natural frequency and can damp machine vibrations without resonance.

Finn & Co., 2850 Eighth Ave., New York, 30, N. Y.



THE "CM-H ISOLATOR" has a load range from 600 to 10,000 lb. It has a height of only 2 in., and has a large surface mounting area.

CONTINUED ON PAGE 168

WHEN FIGHTING A FIRE THERE'S

no time to waste!

IN A FIRE ENGINE THERE IS

no space to spare!

DE LAVAL-IMO HYDRAULIC MOTOR AND WORM GEARS PROVIDE HIGH SPEED, COMPACT, PRECISION CONTROL FOR NEW AMERICAN-LA FRANCE FIRE TOWERS

Because of their unfailing reliability... small size... high efficiency... high capacity... quiet operation... and smooth pulsation-free power delivery... De Laval-IMO hydraulic motors and worm gear reducers are used by American-La France for operating their large aerial fire towers.

If your equipment also requires quiet, reliable, high capacity pumps, motors and gears...investigate De Laval-IMO pumps, De Laval-IMO hydraulic motors and De Laval worm gears. Write for catalog I-158-C.

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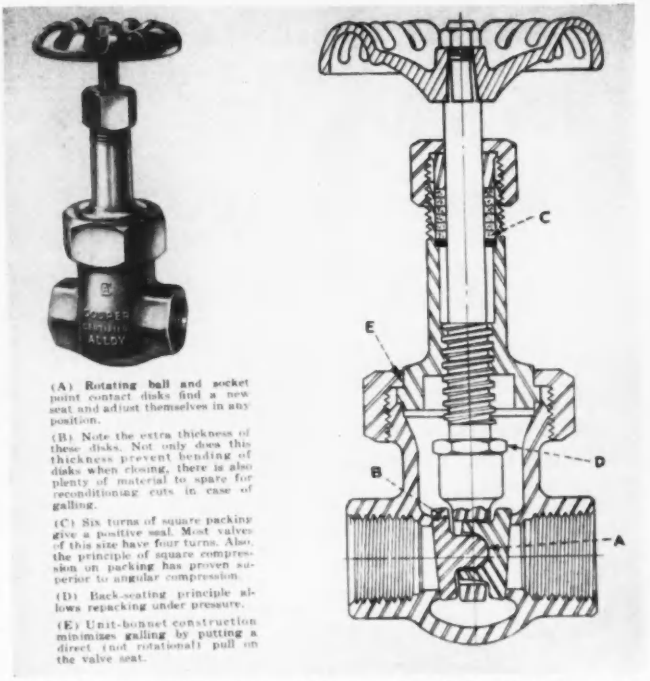
Helena • Houston • KansasCity • St. Paul • LosAngeles • Toronto • NewOrleans • Seattle • SaltLakeCity • Tulsa • Vancouver • Winnipeg • Washington, D.C.

Gate Valve Has Original Equipment Applications

Corrosion, resistance, good appearance, lightweight and economy are important features.

In producing a gate valve to meet the qualifications of the original equipment manufacturers, a clean-cut, functional appearance was a major design objective. For easy polishing and finishing the cast areas were minimized, flat surfaces were used wherever possible, and all small, hard-to-reach recesses and cracks eliminated. Also, especial attention was given to the design of a body casting that combined lightweight with strength.

The Cooper Alloy Foundry Co., Hillside, N. J.



(A) Rotating ball and socket point contact disks find a new seat and adjust themselves in any position.

(B) Note the extra thickness of these disks. Not only does this thickness prevent bending of disks when closing, there is also plenty of material to spare for reconditioning cuts in case of galling.

(C) Six turns of square packing give a positive seal. Most valves of this size have four turns. Also, the principle of square compression on packing has proven superior to angular compression.

(D) Back-seating principle allows repacking under pressure.

(E) Unit-bonnet construction minimizes galling by putting a direct (not rotational) pull on the valve seat.

MADE IN ALL standard stainless steel alloys as well as nickel and Monel metal, this corrosion resistant union bonnet screw end gate valve is available in $\frac{1}{4}$, $\frac{1}{2}$ and 1 in. sizes for working pressures up to 150 pounds per square inch.

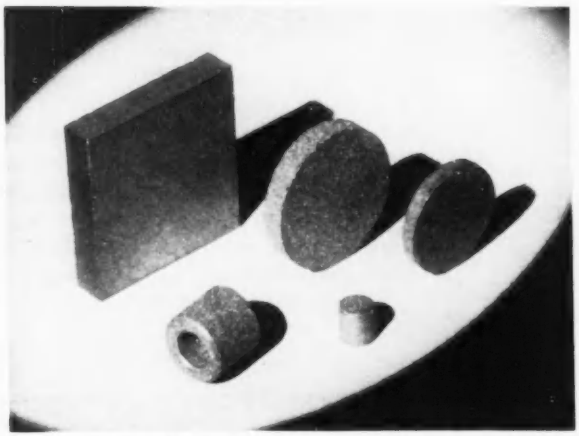
Powder-Metal Stainless Steel Is Used As Filter Medium

Particularly suited to the food and chemical industries, these permanent stainless steel filters are especially designed to handle corrosives or fluids which must not be contaminated.

Made from pure stainless steel powder, the filter forces fluids to travel a tortuous route through a maze of minute connecting passageways running in all directions. Filter units can be easily flushed and are not brittle or friable.

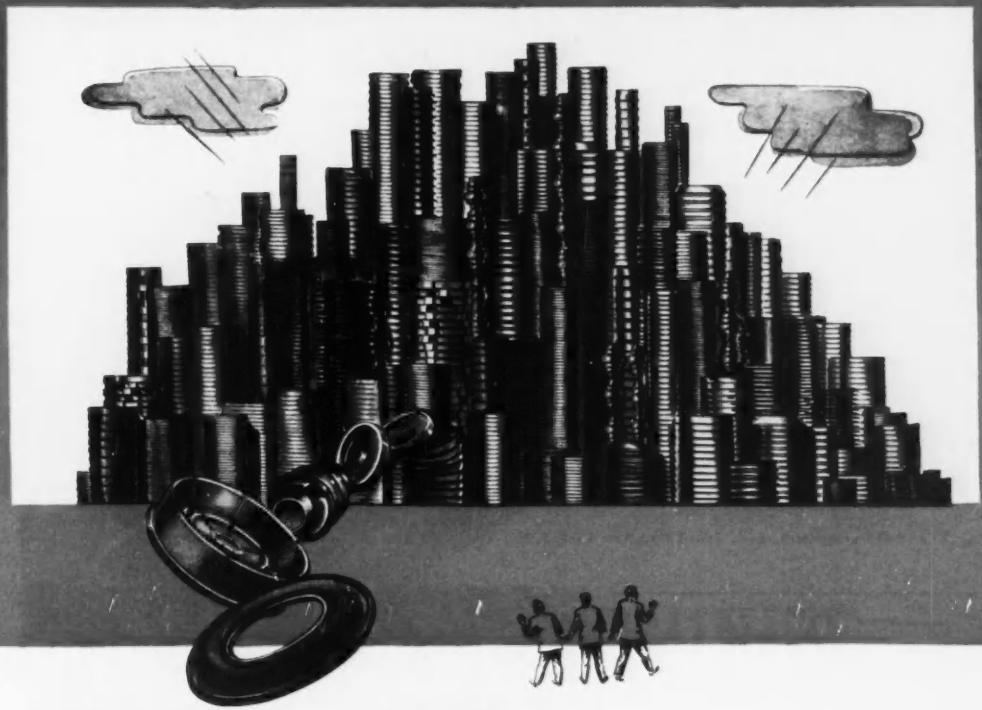
Furnished in wide ranges of porosity, the user can specify a closely controlled permeability from almost 0 to more than 60 percent. Filters are available in all standard shapes.

Amplex Mfg. Co., Div. of Chrysler Corp., Detroit 31, Mich.



TYPICAL STOCK SHAPES are shown. Any special shape required to fit a particular product design can be made to order.

CONTINUED ON PAGE 170



A MOUNTAIN OF SIRVENE

and it's all earmarked

Chances are the Sirvene part you order will be utterly unlike any other. For, while Chicago Rawhide produces literally tons of Sirvene in a year's time, every batch is earmarked for a different pliable part. Each of these parts is designed and developed to do just one special job in a particular mechanism. For every application, Sirvene engineers compound a special formula from pure, oil-resistant elastomers. From it, they mold a custom-engineered part which will fulfill specific requirements in tensile strength, elongation, elasticity or hardness, resilience, and resistance to dryness, moisture, temperature extremes and other deteriorating elements. As a result of laboratory-controlled production methods, Sirvene parts function under unusually severe conditions. That's why engineers across the country depend on Sirvene for their critical pliable parts. Sirvene engineers offer you their unlimited backlog of experience and research. Use it in solving your mechanical elastomer problems.

CHICAGO RAWHIDE MANUFACTURING CO.

1299 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings, and other special molded mechanical pliables

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SIRVENE

THE SCIENTIFIC COMPOUNDED ELASTOMER

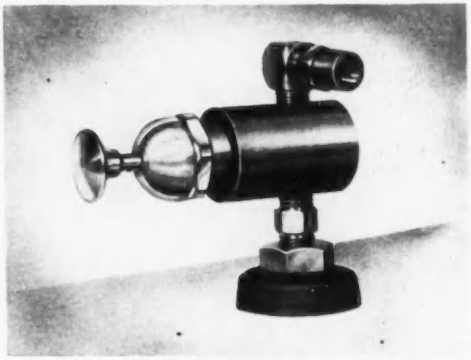
Bijur Announces Miniature "One Shot" Lubricator

Sump mounted unit may be installed in compact areas for measured lubrication of several bearings.

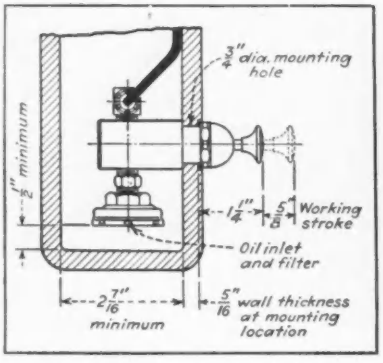
Used where a small group of bearings require accurate, measured lubrication and where space is a consideration, the type LPM "One shot" lubricator connects with the oil sump or reservoir of a machine to service up to six or eight bearings. For a small machine one LPM lubricator may service all bearings. Other more complex machines can use such a unit to advantage when several bearings are isolated or are inaccessible to the main lubricating system.

Using clear, straight mineral oils over a wide viscosity range, the unit filters each "shot" of oil as it is drawn into the chamber. Oils with viscosity ratings from 100 to 1000 sec. Saybolt are commonly used. Normally set to give a discharge of about sixty drops per stroke, the unit can be factory-set to feed any specified amount of oil up to that amount to meet individual customer requirements.

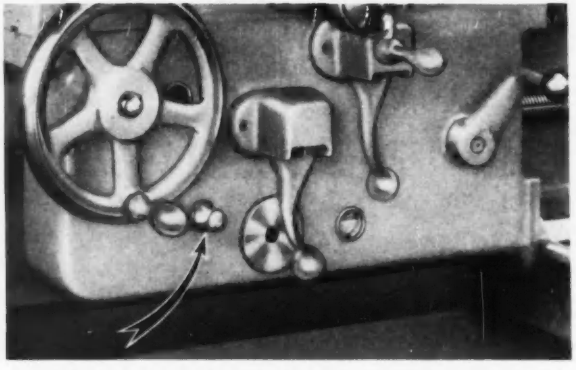
Bijur Lubricating Corp., Long Island City, New York, N. Y.



HUMAN ERROR is eliminated with the use of a lubricator that measures correct amount of oil going to "often forgotten" or "inaccessible" bearings. Unit has a $\frac{1}{2}$ in. dia piston, $\frac{1}{4}$ in. stroke, an average discharge pressure of 30 psi, and a discharge volume of 2 cu cm, or about 60 drops.



SPRING LOADED, the plunger is pulled to fill chamber with 60 drops of filtered oil. Releasing plunger forces oil through outlet valve and into the oil distribution system of the machine.



TYPICAL APPLICATION of LPM lubricator. Mounted in the apron of this lathe, it provides oil for six bearings of the arpon, carriage, and cross slide. The simple construction of the exposed parts blends with modern machine tool design to make the lubricator an integral part of the machine.

Pipe Plug Has Oil-Cleaning Magnet

When this pipe plug is screwed into its receptacle, a small permanent magnet extends on a non-ferrous metal stem into the oil stream of the mechanism. By getting out away from the plug and into the oil stream, it is able to trap fine particles of ferrous abrasive metal and clean the lubricant. Since the magnet is not attached directly to the iron plug, there is no dissipation of the magnetic force.

Magnets have a tractive force of 11 oz. The length of the stem can be varied to allow the magnet to reach into the oil stream at the right place for each application.

All plugs are threaded with the new Dryseal thread, and are completely interchangeable with any standard Briggs type pipe thread. These threads effect a seal without the use of any pipe dopes or compounds of any kind.

The plugs are made in sizes from $\frac{1}{4}$ to $1\frac{1}{2}$ in., and have square, countersunk, or specially designed heads.

The U. S. Plug & Fitting Co., 305 Frederick Bldg., Cleveland 15, Ohio.

CONTINUED ON PAGE 172

When Life's Too Short...

Switch to...

ELECTRUNITE
STAINLESS STEEL TUBING

Available in Types
302
304
316
317
347
309-S
310
430
Other Analyses for Special Applications Upon Request

● Long service life is a primary advantage of Republic ELECTRUNITE Stainless Steel Tubing that pays profitable dividends on your original investment.

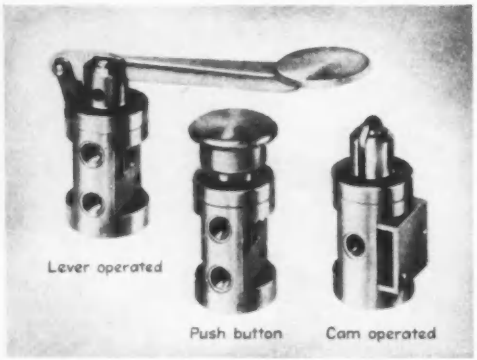
Made of long-lasting ENDURO Stainless Steel, this tubing provides the resistance to heat and corrosion, minimum maintenance expense and sanitary advantages of stainless steel. And as made by Republic's improved welding processes, each length is uniformly round and sound, free from rolled-in scale and scale pits. *Full annealing* of all but ornamental grade assures unvarying high ductility throughout every length—throughout every shipment.

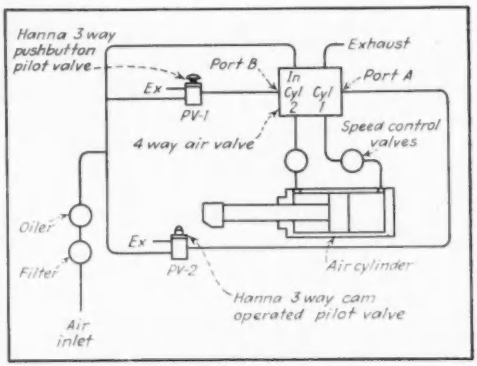
For complete information about these and the many other cost-saving advantages of Republic ELECTRUNITE Stainless Steel Tubing—including a list of sizes, gauges and analyses—write *today* to:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES, CLEVELAND 1, OHIO
Export Dept.: Chrysler Bldg., New York 17, N.Y.

Republic
REPUBLIC STEEL
ELECTRUNITE
STAINLESS STEEL TUBING

New Pilot Valve Series Available





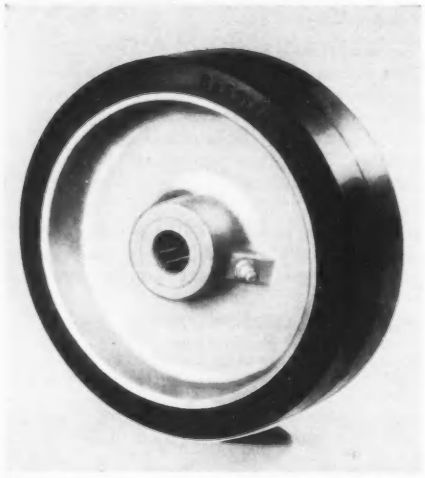
PILOT VALVES are all 3-way and are designed for direct control of small cylinders or automatic indirect control **LEVER OPERATED** valve is for manual control of fast, repeating and continuous operations. Lever can be rotated 90 degrees. **PUSHBUTTON** valve is space saving and is suitable for control panel mounting.

CAM OPERATED valve has a spring loaded roller which may be pushed down by a cam in automatic operations. The roller rotates through 90 degrees. For full or semi-automatic use

TYPICAL APPLICATION DIAGRAM shows a pushbutton pilot valve and a cam operated pilot valve used together to give semi-automatic control of an air cylinder. Pushing the button of pv-1 moved the piston to the left. The cam surface on the piston strikes the roller on pv-2 and moves the piston to the right. These pilot valves are available with all three port holes tapped for $\frac{1}{4}$ in. pipe. The valves are $1\frac{1}{8}$ in. in dia, and are from $3\frac{3}{4}$ to 4 7/16 in. high, depending on the type of actuating mechanism. A bracket for side mounting is optional.

Hanna Engineering Works, 1765 Elston Ave., Chicago 22, Ill.

Bassick Announces Line of Aluminum Cored Wheels



CALLED "ALCORE", these wheels feature a weight reduction, cost saving, and a clean appearance. Caged type roller bearings are used in the wheels.

Wheel Dia.	Load Cap. lb.	Catalog No.	Tread Width	Hub Length	Bore	Bore with Spanner Bushing	Weight, lb.
6"	230	WR-7726	$1\frac{1}{2}$"	$1\frac{3}{4}$"	$\frac{5}{8}$"	..	2
	230	WR-7736	$1\frac{1}{2}$"	$1\frac{3}{4}$"	$\frac{3}{4}$"	..	2
	340	WR-7706	2"	$2\frac{3}{8}$"	$\frac{3}{4}$"	$\frac{1}{2}$"	$2\frac{1}{4}$
	340	WR-7756	2"	$2\frac{3}{8}$"	$\frac{7}{8}$"	..	$2\frac{1}{4}$
8"	420	WR-7708	2"	$2\frac{1}{4}$"	$\frac{3}{4}$"	$\frac{1}{2}$"	4
	420	WR-7718	2"	$2\frac{1}{4}$"	$\frac{7}{8}$"	$\frac{5}{8}$"	4
	420	WR-7728	2"	$2\frac{1}{4}$"	1"	..	4
	560	WR-7748	$2\frac{1}{2}$"	$2\frac{3}{4}$"	$\frac{3}{4}$"	$\frac{1}{2}$"	5
	560	WR-7758	$2\frac{1}{2}$"	$2\frac{3}{4}$"	$\frac{7}{8}$"	..	5
	560	WR-7768	$2\frac{1}{2}$"	$2\frac{3}{4}$"	1"	..	5

WHEELS are also available in 12 in. size. Specifications are comparable with those shown above for the 6 and 8 in. sizes. The treads are made of a resilient rubber compound. Special sizes and tread compounds are available on quantity orders. Notice the weight of these wheels. They average almost 50 percent lighter than conventional wheels with iron or steel cores. All load ratings are in keeping with the Tire & Rim Association and are comparable with steel wheels.

The Bassick Company, Bridgeport, Conn.

CONTINUED ON PAGE 174

More OEM's* Specify US Gauge Than Any Other Make!

* Original Equipment Manufacturers

. . . Because USG Assures More Value

Throughout industry, the story is the same from year to year. Original equipment manufacturers (OEM's) demand substantial gauge value . . . accuracy, durability, and quality at economy prices . . . and 6 out of 10 specify US Gauges.

They know that US Instruments give more service, more accuracy, more *value* for the money. They know USG can supply all their needs—from highly specialized instruments measuring as low as 1" of mercury absolute, to standard type gauges measuring from 30" vacuum to 100,000 pounds pressure per square inch. And they know that for more than 40 years US Gauges have been the standard of dependability. So more original equipment manufacturers specify US Gauges than any other make.

Next time you order gauges, follow the lead of these satisfied users . . . buy US Gauges. For more information about US Gauge write today. United States Gauge, Division of American Machine and Metals, Inc., Sellersville 24, Penna.

US GAUGES—BETTER INSIDE . . . BETTER OUTSIDE . . . BETTER ON YOUR PRODUCT

USG

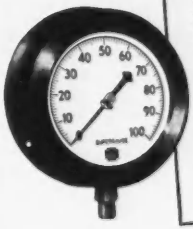
UNITED STATES GAUGE

SOLID FRONT GAUGES

A complete line of large size solid front gauges for use with all gases. In these gauges a solid wall separates the bourdon tube and movement section from the dial to give maximum protection to observer. Entire back of case is fitted with a spring-mounted safety release plate which will discharge the pressure media away from observer if bourdon tube ruptures. Tubes of selected beryllium copper with threaded socket and tip connection. Deep bushed stainless steel movement. Ranges: 30 to 5,000 lbs. p.s.i.

CHEMICAL GAUGES
(Clean-out & Protected Types)

For use with any media whose viscosity may require provision for periodic cleaning of gauge. Upper housing is of alloy steel with a specially designed seat to receive the corrosion resistant diaphragm on a tapered fit, metal to metal seal. Diaphragms are available in stainless steel, aluminum, tantalum, Neoprene and in silver and other precious metals. Mounting flange supplied as standard in forged steel. Ranges: 30" vacuum to 400 lbs. p.s.i.

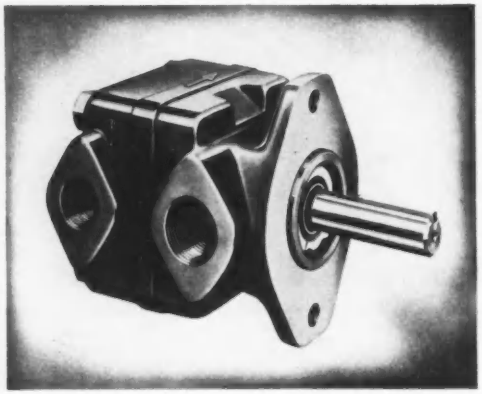


ELECTRIC ALARM GAUGES

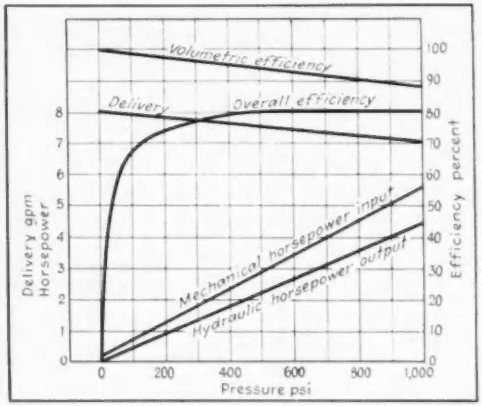
Pressure actuated, high-capacity, snap-action switches with accurate repeatability and low switching differentials. For use on hydraulic pumps, presses, etc., or for use as a signaling or control mechanism for low and high tank levels or pressures. Type W is a non-indicating switch containing 2 independent, single pole, double throw switches actuated from a single bourdon tube. Type Wi is identical to type V but is equipped with a second independent bourdon tube so that the indicated pressure is entirely independent of the element actuating the switches. Ranges: 0 to 30" vacuum, 15 to 20,000 lbs. p.s.i.

PRODUCTS OF UNITED STATES GAUGE . . . Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges • Chemical Gauges • Dial Thermometers • Glass Tube Thermometers • Flow Meters • Inspectors' Test Gauges • Laboratory Standard Test Gauges • Marine, Ship and Air-Brake Gauges • Recorders • Controls and Alarm Gauges • Voltmeters • Ammeters • Welding Gauges

Hydraulic Pump Is Designed for Mobile Equipment



Balanced vane pumps are made with capacities ranging from 2 to 11 gpm, and in standard, foot, face, and flange mounted models. Pumps in all four capacity ratings have the same exterior dimension and the same weight. Pump housings are alloy iron and all working parts are alloy steel. There is no starting load because the vanes are not extended and pumping does not begin until after the engine comes up to speed.



AVERAGE PERFORMANCE CURVES are shown for the V-210-8-1C pump at 1,200 rpm. Other models show similar characteristics. For these tests an oil was used with a viscosity of 150 S.S.U. at 100 F. For best operation, oils ranging from 150 to 225 S.S.U in viscosity and temperatures of 100 F are recommended. Operating pressures should not exceed 1,000 pounds per square inch.

Pump Model Numbers				Pump Characteristics at 1,200 rpm Characteristics at Other Drive Speeds Approximately Proportional to rpm						Recommended Drive Speed, rpm		
				Min. Delivery gpm			Horsepower Input					
Standard Mounting	Foot Mounting	Face Mounting	Flange Mounting	0 psi	500 psi	1,000 psi	0 psi	500 psi	1,000 psi	Min. Starting	Max. Continuous	Max. Intermittent
V210-2-1C	V214-2-1C	V230-2-1C	V235-2-1C	2.4	2.0	1.6	.2	1.4	2.4	600	2250	2750
V210-5-1C	V214-5-1C	V230-5-1C	V235-5-1C	5.5	5.0	4.6	.25	2.2	4.0	600	1800	2200
V210-8-1C	V214-8-1C	V230-8-1C	V235-8-1C	8.0	7.5	7.0	.25	2.9	5.5	600	1600	1900
V210-11-1C	V214-11-1C	V230-11-1C	V235-11-1C	11.2	10.6	10.0	.3	4.0	7.5	600	1200	1400

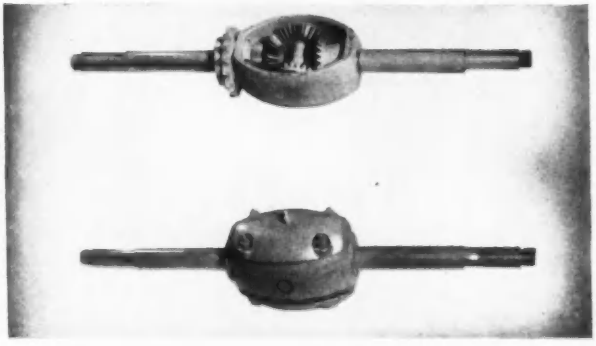
Vickers, Incorporated, 1454 Oakman Blvd., Detroit 32, Mich.

Simple, Low Cost Differential Available

Made primarily for use with farm equipment, this differential is supplied with either an open or closed gear box.

For light applications the unit has unhardened gears and a cast iron gear box. This design allows a rating of 300 ft lb. If an application requires up to 700 ft lb, the unit can be furnished with heat treated gears and a cast steel gear box. Differentials can be driven by worm or spur gears.

George Tractor Div., Community Industries Ass'n., 811 Hamilton St., Sullivan, Ill.



CONTINUED ON PAGE 176

54 EVERDUR WELDS for extra strength and rigidity . . .

TOTAL WELDING TIME: FIVE MINUTES

Electrically spot-welded Harrison Steel Kitchen Cabinets being carbon arc welded with Everdur rod. Circles on finished cabinets, below, indicate 54 points where members are reinforced.

THIS is the way Vincent Russo, Superintendent of the Harrison Steel Cabinet Company of Chicago, tells the story:

"Although our steel cabinets are electrically spot-welded throughout, we have found that carbon arc welding the corners and joints with Everdur* rods assures the additional strength and rigidity a quality item deserves.

"Years ago we found that by bronze-welding our drawer guides in the cabinets, rather than screwing them in place, not only was added rigidity obtained, but we eliminated the possibility of drawers getting out of line because of loosened screws.

"In our average-size sink and wall cabinets there are a total of 54 carbon arc welds made with Everdur rod. While this seems excessive, our actual welding time is less than five minutes, due principally to the low melting point of this copper-silicon alloy rod. The additional cost of this welding is far overshadowed by the extra strength and added quality."

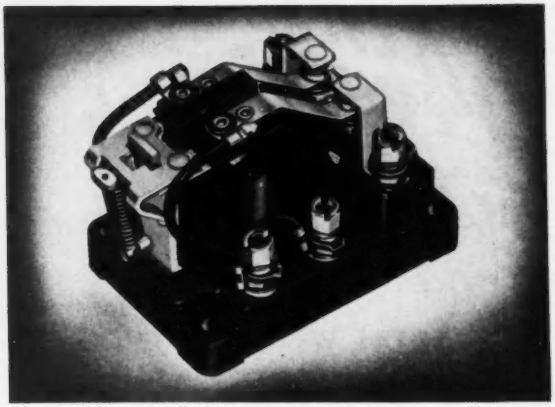
Anaconda Welding Rods are available in a wide range of alloys suitable for many oxyacetylene or arc welding purposes. They are fully described in Anaconda Publication B-13. For your copy write to The American Brass Company, Waterbury 88, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 49155

*REG. U. S. PAT. OFF.

You can depend on ANACONDA

BRONZE WELDING RODS

Ward Leonard Announces Midget Relay



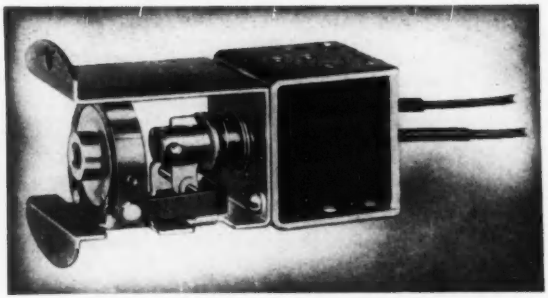
Called the Bulletin 110 Multiple Midget Magnetic Relay, this component is designed for such general purpose applications as traffic signal, machine tool, alarm and heater control.

Features include: long mechanical life, sturdy construction, self-cleaning, self-aligning contacts, and corrosion protected metal parts. Standard 2 or 3 pole double throw relays have molded phenolic insulating bases, screw terminals for front connection and heavy silver to silver contacts. Leads from movable leaf spring contact fingers to terminals are insulated with Fiberglas tubing.

Coils are available for operation on all standard voltages and frequencies up to 115 v, ac or dc. Non-inductive ratings for normally open or normally closed contacts are 10 amps, 24 v, dc or 115 v, ac, 60 cycles. Plug-in type bases are available on special order.

Ward Leonard Electric Company, Mount Vernon, N. Y.

Small Brake Quickly Stops FHP Motors



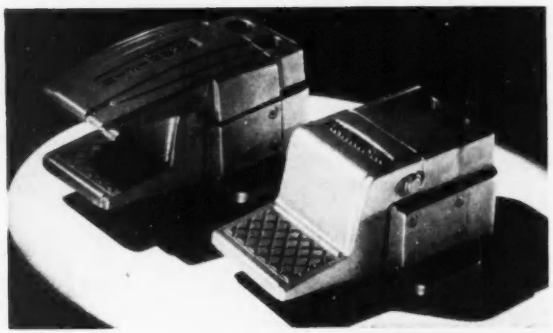
Stopping the average small gear head motor in less than 10 deg of rotation, this solenoid operated brake gives smooth operation with no overshooting or coasting.

The unit consists of a standard solenoid which operates a cam and spring lever to tighten or release a phosphor bronze brake band. The brake drum is connected to the motor shaft opposite the gear head.

The solenoid is actuated at the same time as the motor, and acts to release all braking action. A break in the circuit allows the band to close.

Guardian Electric Manufacturing Company, 1621 West Walnut St., Chicago 12, Ill.

Light Pressure Actuates New Valve



Made especially for the control of double-acting air cylinders, this new model NFS "Directair" valve directs compressed air alternately to two pressure ports to energize the air cylinder.

The foot pedal operates only a small pilot valve and moves less than $\frac{3}{4}$ in. under a slight foot pressure. The sliding, self-lapping main valve disk is shifted by a reciprocating light metal piston, which is moved by alternately admitting line pressure to one end and venting the other.

These valves operate with air pressures ranging from 25 to 150 psi. Models are now being manufactured in $\frac{1}{2}$ and $\frac{3}{4}$ sizes.

Safety pedal guards are optional equipment.

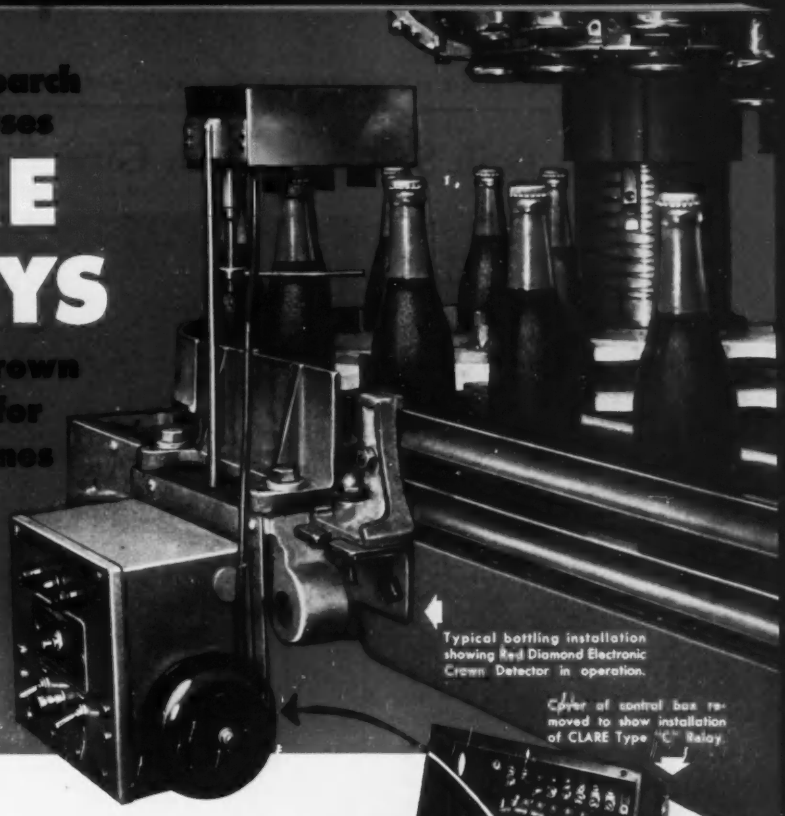
Hannifin Corporation, 1126 South Kilbourn Ave., Chicago 24, Ill.

CONTINUED ON PAGE 178

Industrial Research Laboratories uses

CLARE RELAYS

in Electronic Crown Detector Unit for Bottling Machines



Typical bottling installation showing Red Diamond Electronic Crown Detector in operation.

Cover of control box removed to show installation of CLARE Type "C" Relay.

Send for CLARE Engineering Data Book

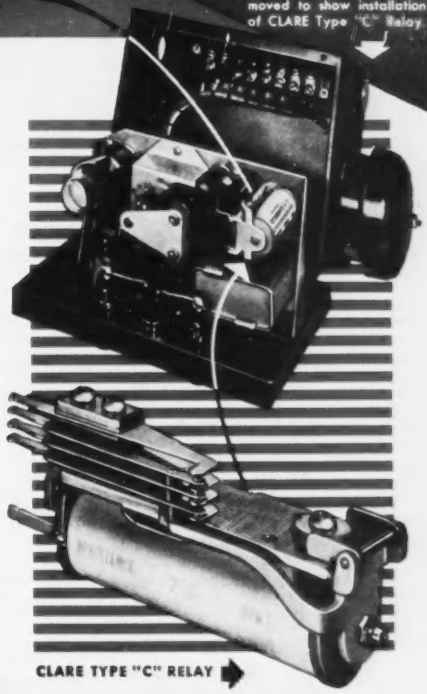
This book, sent on request, pictures and describes the complete CLARE line of relays and allied control apparatus to meet the widest variety of industrial uses.

This electronic device warns of any interruption of the crown supply in bottling operations. It is sold by Liquid Carbonic Corporation of Chicago and manufactured by Industrial Research Laboratories of Baltimore, Md.

A bottle feeler switch is inserted in the control grid circuit to close the circuit when a bottle passes between the poles. If a crownless bottle passes, an electronic tube momentarily operates the CLARE Type "C" Relay and an alarm sounds for a few seconds. Passage of the second crownless bottle causes the CLARE relay to stop the machine on the second operation.

CLARE relays were selected by Industrial Research Laboratories for this important operation because of their long reputation for accurate, long-life performance as components of devices designed for trouble-free operation, day in and day out. In larger plants, more than a million bottles per week pass through the machine.

If you have a difficult relay problem, a requirement where ordinary relays just won't do, why not take it up with our engineers? CLARE sales engineers are located in principal cities. They are experienced in the most difficult types of relay problems. We invite you to take advantage of their services. Call them direct . . . or write to C. P. Clare, 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials Ltd., Toronto 13. Cable address: CLARELAY.



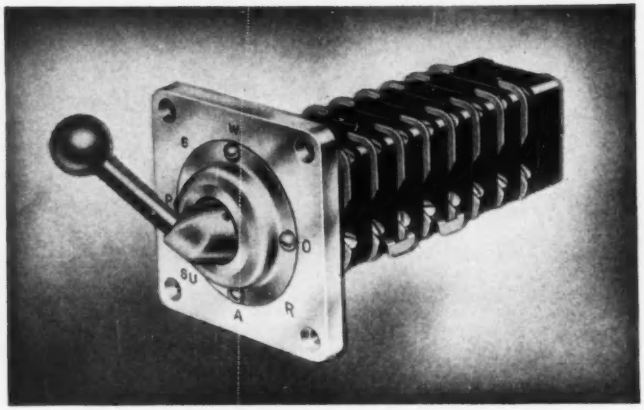
CLARE TYPE "C" RELAY

CLARE RELAYS

First in the Industrial Field

Custom Built Selector Switch Gives Simple Control

Low initial cost, smaller control panels, elimination of push-buttons and reduction of relays and starters are features.



This master switch quickly, easily and positively responds to the operator's selection in eight, sixteen, or more positions. Pulling the handle in the selected position starts the desired function; pushing the handle stops the action.

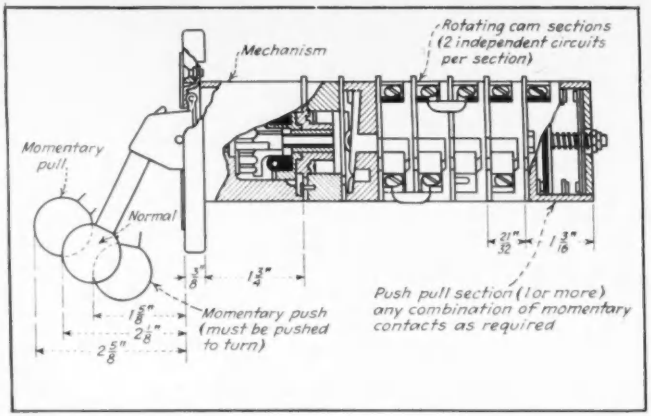
In these Push-Pull-Selector switches, the push motion drops out the starters before the load connections can be changed. This prevents simultaneous operation in two or more positions. Turning establishes the desired load connections, and the pull motion then energizes the starters.

Since this switch is custom built, almost any quality or combination of qualities needed for a particular application can be built into the unit.

FEATURES:

1. Provides a single point of operation for a multiple operation machine.
2. Ability to move from any position of the dial to any other point without having any of the intervening operations take place.
3. Control and load circuits may be combined in as many rotating cam sections as are required. 30 amps per circuit carrying ability.
4. Two completely independent circuits per section. Each can be opened or closed individually.

The Arrow-Hart & Hegeman Electric Co., Hartford, Conn.

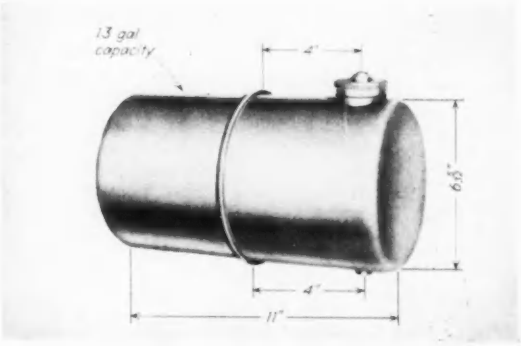


Fuel Tanks Have Single Seam

Made from extra drawing terne plate, these one-seam tanks are rust-resistant and rigid. Each tank has been pressure-tested for leaks at 15 psi. Their most common application will be with gravity-fed engines where the gas tank must be mounted high in a conspicuous position. Simple, clean construction should make the unit an attractive part of any power-driven machine.

Capacities of the various models range from ½ to 6 gallons. The illustration shows a 1.3 gal. tank. Other tanks of different capacities are available in proportionate dimensions.

Donaldson, Inc., 666 Pelham Boulevard, St. Paul, Minn.



CONTINUED ON PAGE 180

WITH PERMITE ALUMINUM CASTINGS

A change from heavy metal to lightweight Permite Aluminum Castings can bring you these definite cost cutting savings:

1. Save on Cost of Handling

Permite Aluminum Castings are approximately 60% lighter than cast iron and 65% lighter than steel, brass and bronze. They're lighter to handle, lighter to assemble, lighter to ship as a finished product. So you cut handling costs all along the line!

2. Save on Cost of Finishing

The consistent uniformity of Permite Aluminum Castings within close tolerances makes only a minimum of machining necessary. Higher machine speeds and deeper cuts are practical with Permite Aluminum Castings, with only slight changes in tool contours. Time spent per unit in shaper, drill press or milling machine is appreciably less! And aluminum stays bright without painting or expensive plated coatings.

3. Longer Service, Fewer Replacements Mean Long-Range Savings

High tensile strength; resistance to corrosion; rapid heat transfer; and special to-fit-the-job designing by Permite engineers enable Permite Castings to give longer, better service! You save three ways with Permite and get better appearance, a better product.

PERMITE

Why not write us about your castings requirements and get our recommendations and quotations?

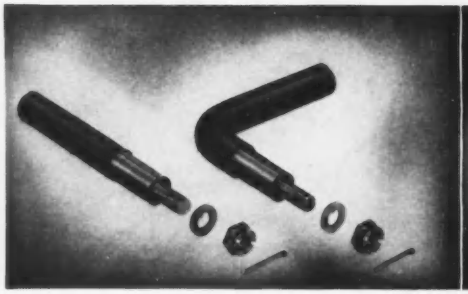
ALUMINUM INDUSTRIES, INC.

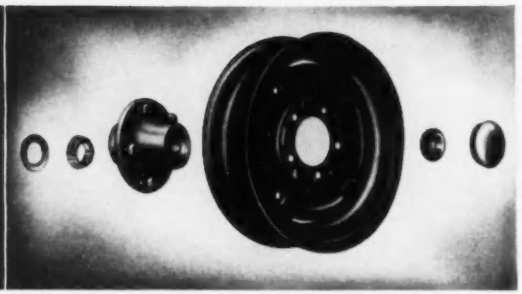
CINCINNATI 25, OHIO

DETROIT, 809 New Center Building, NEW YORK, 9 Rockefeller Plaza, CHICAGO, 64 E. Jackson Boulevard, ATLANTA, 455 Grant Building

ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS

Kelsey-Hayes Offers Disk Wheels In Complete Kit





USED ON TRAILERS, wagons, sprayers and other mobile equipment, this wheel kit is complete with rim, disk, hub bearing cones, grease seal and cap and other such parts. The spindle may be either straight or bent and the units may be ordered with or without brakes. However, brakes are not available for the light duty sizes.

Classification	Load Range	Tire Size
Light	1,200–1,500 lb	6.00 x 9; 5.00 x 12; 5.50 x 16; 6.00 x 16; 6.50 x 16
Medium	1,500–1,750 lb	9 x 4.00; 15 x 5.00; 16 x 4.00; 16 x 4.50; 16 x 5.50
Heavy	1,750–2,000 lb	9 x 4.00; 15 x 5.00; 16 x 4.50; 16 x 5.50

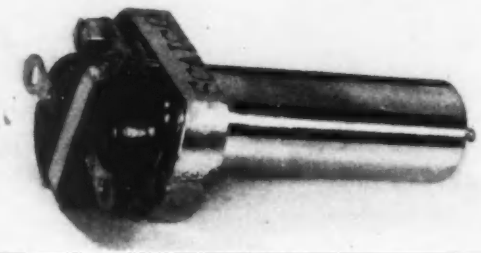
French & Hecht Division, Kelsey-Hayes Wheel Company, Davenport, Iowa

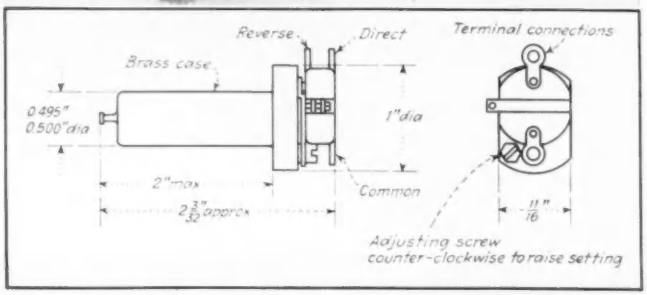
Liquid Expansion Thermostat Features Close Differential

Developed originally for aircraft use, this unit features the relatively close differential for a snap-action type of thermostat of ± 4 F. It can be used as a control for electric heaters, relays, motors, and other usual applications. Temperature ranges are from 70 to 300 deg Fahrenheit.

OPERATING CHARACTERISTICS:

1. Snap Action—Single Pole Double Throw
2. Differential ± 4 F.
3. Degrees Per Turn Adjusting Screw 7 F.
4. Undershoot—Unlimited
5. Overshoot 20 F Above Set Point
6. Direct and Reverse Acting in Same Unit
7. Underwriters' Laboratories Approved Rating 10 amps 115 v-ac. 5 amps 230 volts, alternating current.





Smith Control & Instrument Corporation, 1329 Highland Avenue, Needham 92, Mass.

CONTINUED ON PAGE 182

Where Quality Counts!

In the Electrical Industry

where long service life and reliability under adverse operating conditions are essential, Silicone-glass laminates* have many actual and potential uses because of their unique properties.

1. *Flexural Strength, psi, 12,000 to 15,000.*
2. *Heat Limit, Continuous use, °C., more than 250.*
3. *Water Absorption, %, less than 1*
4. *Arc Resistance, seconds, more than 240.*
5. *Wet insulation resistance, megohms (after 48 hours immersion), 100,000.*

In Household Appliances

A woman may be won by appearances—but she also demands a life-time of service. That's why Camfield engineers specified Silicone-glass laminate* for the terminal block and contactor base in the new Camfield 1950 Toaster with Tete-a-Tete Controls.

Their own testing proved that Dow Corning Silicone Resin bonded glass laminates are more rigid, more heat-stable, more resistant to moisture and easier to fabricate and assemble than conventional materials.

MICO ELECTRICAL INSULATION
TRADE MARK

 # 6091 LAMICOID® MANUFACTURED BY

MICA Insulator COMPANY
Schenectady 1, New York

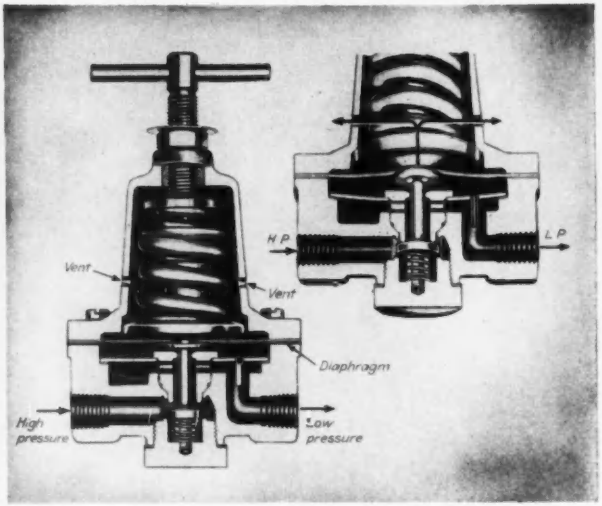
Dow Corning
FIRST IN SILICONES

** WITH SILICONE RESINS BY*

DOW CORNING CORPORATION
MIDLAND, MICHIGAN

Fluid Pressure Regulator Has Built-In Relief Valve

Reduces line pressures to close working pressures with assurance against "creep."



FOR USE on lines carrying air or non-corrosive gases, oils, or water, this regulator will operate on line pressures up to 400 psi. It gives a closely controlled working pressure up to 250 psi. Designed especially for "dead-end" service, it may also be installed as original equipment on production machines requiring precise pressure control with no "creep".

AIR PRESSURE in the diaphragm area exceeds the regulated pressure and raises the lower spring rest to pull the relief valve air vent from its pin. Excess air then goes into the bonnet and out the breather holes. When the air in the diaphragm area has returned to its regulated pressure, the lower spring rest is reseated on the valve pin, closing the valve. The lower spring rest is not rigidly clamped to the diaphragm, but is free to float, thus automatically adjusting to any eccentricity. This gives close pressure control. Valves are available in six sizes, from ¼ to 1 in. for secondary pressures from 15 to 250 psi.

C. A. Norgren Company, 222 Santa Fe Drive, Denver 9, Colo.

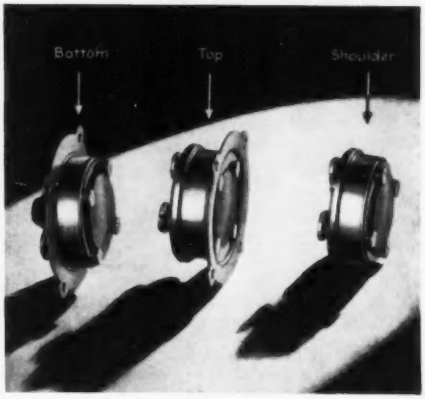
Snap Action Thermostats are Totally Enclosed

Providing protection against oil, dust, or other contaminating substances, this line of fixed temperature thermostats can be mounted in space, or in recessed wells, in castings, on flat surfaces or in sheet metal enclosures for control of air temperatures. They can be supplied with various temperature differentials in settings from—10 to 550 F, and are provided with bottom, top, and shoulder mounting flanges.

They may be used for the heat control of unit and space heaters, small water heaters and other products requiring non-adjustable temperature controls.

Operating on the snap-acting disk principle, these units do not require over center-toggle mechanisms, magnets, or other expensive and complicated parts.

Called the C 4370, this line of thermostats has a motor load rating of ¼ hp, 120-240 v-ac and a pilot duty rating of 125 volt-amperes, 120-240 v-ac. Additional Underwriters' rating include 12 amps, 120 v-ac and 6 amps, 240 v-ac. For dc ratings, recommended maximums are 12 amps 30 v-dc and 1 amp, 125 v-dc. All types are ground tested with 1,500 v, alternating current.



CONTINUED ON PAGE 184

Better Your Products with

Michigan WELDED STEEL TUBING

The Modern Electric Resistance Welded Steel Tubing

A STAIR
AND
EVERYWHERE
Michigan Welded Steel Tubing is used Extensively in the manufacture of Products Large and Small, for Home and Business.

Thousands of manufacturers use Michigan Electric Resistance Welded Steel Tubing to produce better products at lower cost. Available in a wide variety of shapes and sizes for almost any application. For reasons of design simplifications, fabricability, uniformity, ductility, ease of assembly and installation, Michigan tubing cannot be surpassed for working in your plant or prefabricated by Michigan.

ROUND

¼" to 4" O. D. 9 to 22 gauge

SQUARE-RECTANGULAR

½" to 2" 20 gauge 1" to 2¾", 14, 16, 18 gauge

Can be Bent, **FLANGED, EXPANDED, TAPERED, DEPRESS BEADED, ROLLED, EXTERNAL UPSET, INTERNAL UPSET, SPUN CLOSED, FORGED, BEVEL FLANGED, FLATTENED, SWAGED, FLUTED, EXPAND BEADED**

A Quality Product

RESISTANCE WELDED STEEL TUBING

Michigan STEEL TUBE *PRODUCTS CO.*

THE OLDEST NAME IN ELECTRIC

For Engineering advice and technical help in the selection of tubing best suited to your needs consult us.

33 Years in the Business

9450 BUFFALO STREET • DETROIT 12, MICHIGAN

FACTORIES: DETROIT, MICHIGAN • SHELBY, OHIO

DISTRIBUTORS: Steel Sales Corp., Detroit, Chicago, St. Louis, Milwaukee, Indianapolis and Minneapolis—Miller Steel Co., Inc., Hillside, N. J.—C. L. Hyland, Dayton, Ohio—Dirks & Company, Portland, Oregon—James J. Shannon, Milton, Mass.—Service Steel Co., Los Angeles, Calif.—American Tubular & Steel Products Co., Pittsburgh, Pa.—Strong, Carlisle & Hammond Co., Cleveland, Ohio—Drummond, McCall & Co., Ltd., Toronto, Canada.

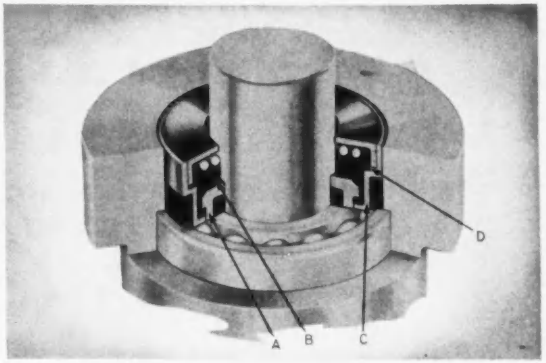
Packaged Unit Shaft Seal Is Complete Cartridge

Containing both stationary and rotating seal members, this unit seal eliminates wear on shaft, bearing race, or other surfaces normally exposed to sliding friction.

There is no need to provide a hardened or lapped rotating seal surface of any kind when using a Unit seal. The complete assembly can be quickly installed without extensive cavity preparation.

Seals are available in shaft sizes from ½ in. up to 2¼ in. Since the inside dia of the rotating seal ring is variable, it can be modified to cover a range of shaft sizes without changing the size of the seal case. When ordering, it is best to submit dimensioned drawing and complete operating data.

Gits Brothers Manufacturing Company, 1832 S. Kilbourn Ave., Chicago 23, Ill.



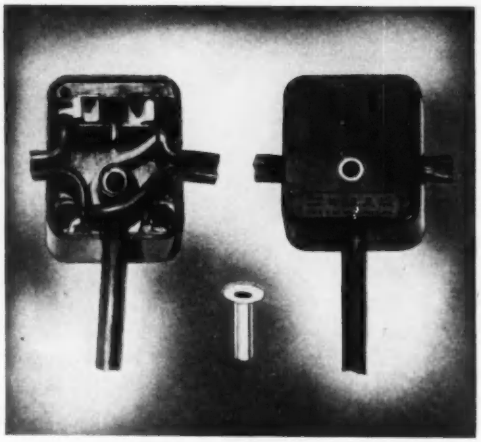
(A) Rotating metal sealing ring contains resilient gasket. This ring rotates with the shaft. (B) Stationary seal nose bears against rotating member. Diaphragm is bonded to seal nose. (C) Case contains rotating and stationary sealing surfaces. (D) Diaphragm keeps lapped surfaces in contact, under spring pressure.

Junction Block Has Wells To Segregate Splices

Using three separate "wells" to partition splices, this new junction block practically eliminates short circuits due to stray strands or faulty soldering.

This thermosetting junction block is called Nu-Blok, Jr. It will find its greatest use in the disconnect junction wiring of freezers, refrigerators, water coolers and industrial machinery of comparable size. The outside dimensions are 2 x 1¾ x ⅞ in. A brass eyelet secures a laminated phenolic cover and serves as a channel for a No. 10 mounting screw or bolt. All parts conform with standards established by the Electrical Underwriters' laboratory for overall dimensional thickness, dielectric strength, and heat resistance.

United Manufacturing & Service Company, 405 South Sixth St., Milwaukee, Wis.



Full-Voltage Starter Is Used in Corrosive Atmospheres

This new starter has its entire mechanism immersed in oil and sealed from the atmosphere. It is weatherproof and can be used for outdoor installations. The starter enclosure is entirely corrosion resistant; the head casting is of aluminum alloy, all exposed hardware is stainless steel, and the steel tank is coated with aluminum paint on the outside and marine spar varnish within. Built for simple installation and easy inspection, the starter controls squirrel cage motors and the primary of wound rotor motors of 350 hp or less at 2,300 volts. It is actuated by a pilot device, such as a push button, float, or pressure switch.

Either undervoltage protection or release may be incorporated in the control circuits used in conjunction with the starter. A built-in drum type multi-stage auxiliary switch provides for extra circuits when desired in the control system. A portable tank lifter for easy, simplified inspection is available as optional equipment.

Allis-Chalmers Mfg. Company, 1002 South 70th St., Milwaukee, Wis.

CONTINUED ON PAGE 186

Time and Cost Saving Features

TYPE "A" ASSEMBLY BIT

COMMON SCREWDRIVER

ON WHICH CLUTCH HEAD CHALLENGES COMPARISON WITH ANY AND ALL OTHER SCREWS

1. ***What Other Screw*** equals the high visibility of the CLUTCH HEAD recess to check out the slow-down of hesitation . . . even with "green" operators?
2. ***What Other Screw*** frees the line from burred and chewed-up heads with automatic straight driving . . . with Center Pivot entry that prevents driver canting?
3. ***What Other Screw*** has a non-tapered driving engagement (without dangerous "ride-out" as set up by tapered driving) to eliminate the hazard of skid damage? . . . and the need for fatiguing end pressure?
4. ***What Other Screw*** provides a simple Lock-On which unites screw and bit as a unit to hurdle "fumble spots" by permitting one-handed reaching and driving from any angle?
5. ***What Other Driver*** can begin to approach the durability record of the rugged Type "A" Bit . . . 214,000 screws driven non-stop?
6. ***What Other Assembly Bit*** can be *repeatedly* reconditioned on the spot by a 60-second application of the end surface to a grinding wheel . . . for unmatched tool economy.
7. ***What Other Modern Screw*** has a recess basically designed for operation with a common screwdriver . . . for the simplification of field service adjustments?

According to users of CLUTCH HEAD *Screws, you may confidently expect these time- and cost-saving features to deliver assembly production increases ranging from 15% to 50%.*

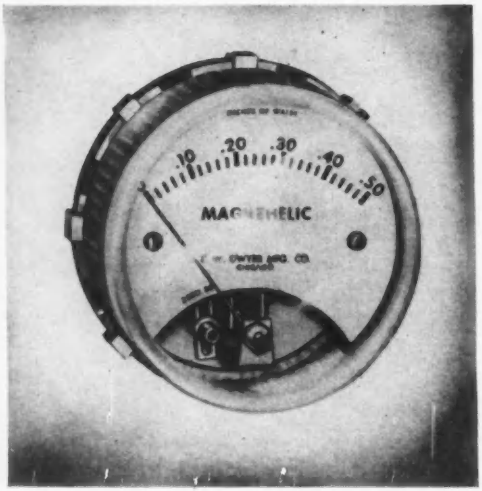
CLUTCH HEAD SCREWS

The New CLUTCH HEAD *Brochure details and illustrates the exclusive advantages of America's Most Modern Screw. Your copy will come to you by mail on request . . . mentioning the types and sizes of screws in which you are interested.*

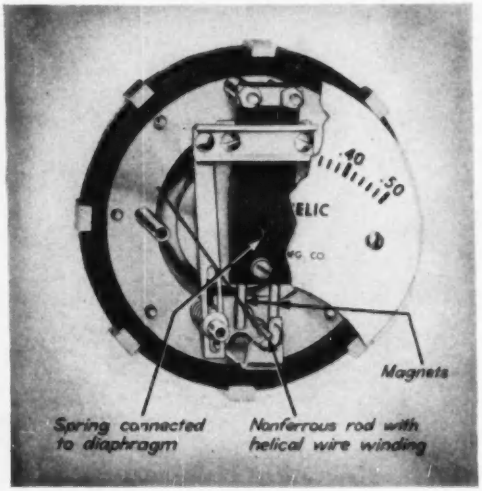
UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

Extreme Sensitivity Featured In Air Gage



USED for the measurement of air pressures, typical applications for this "Magnehelic" gage include furnace draft checking, testing filter resistance in ventilators of air conditioning equipment, measuring static pressure and air delivery of fans or blowers, and other such air velocity measurement, from 400 to 10,000 fpm. In spite of extreme sensitivity, this gage is not a delicate instrument and no special precautions are needed in handling it. This makes the gage useful for either portable or permanent use on flow meters, automatic valves, etc. Connections may be made with rubber tubing, ¼ in. pipe or ¼ in. tubing. The gage may be used in any position, including upside down.



FLEXIBLE DIAPHRAGM is attached to a spring which supports two permanent magnets (see illustration). As these two magnets are moved forward or backward by the spring, the helical wire winding between the magnets assumes a position in which the magnetic force can travel through a minimum air gap. This action moves the pointer and indicates the reading. Movements of the magnets as small as 0.00025 in. are reflected in minute movements of the pointer. The pointer assembly has jewelled bearings for greater accuracy. The range is from ½ to 12 in. of water. Reading may be either plus, minus, or differential, depending on the application.

F. W. Dwyer Mfg. Company, 317 S. Western Ave., Chicago 12, Ill.

Multi-Point Pyrometer Gives Temperature at Six Points

Designed for indicating temperatures at one to six different thermocouple locations, this pyrometer operates at ranges from —300 to + 300, 75 to 400, 1,000 to 1,600 and up to 2,300 F. Scales calibrated in the centigrade scale are also available.

Models are calibrated in Iron Constantan, Chromel Alumel or Copper Constantan, depending on the temperature range desired.

A polarized, quick coupling plug connects the pyrometer to any one of the six thermocouple jacks. Since these plugs and jacks are all of thermocouple materials, there is no danger of errors produced by connections of dissimilar materials.

This pyrometer panel assembly is designated model 10252. It is compactly designed for flush mounting on instrument panel boards. Dimensions are 5¾ in. in width and 9 in. in height. The black Bakelite panel has white numerals for easy reading.

The assembly is automatically compensated for cold junction temperature resistance coefficient. The movement was designed to give accurate readings in low temperature ranges of 75 to 400 and —300 to +300 deg F.

Thermo Electric Co., Inc., Fair Lawn, N. J.

CONTINUED ON PAGE 188

Save time on machine design
...specify the complete CRANE line

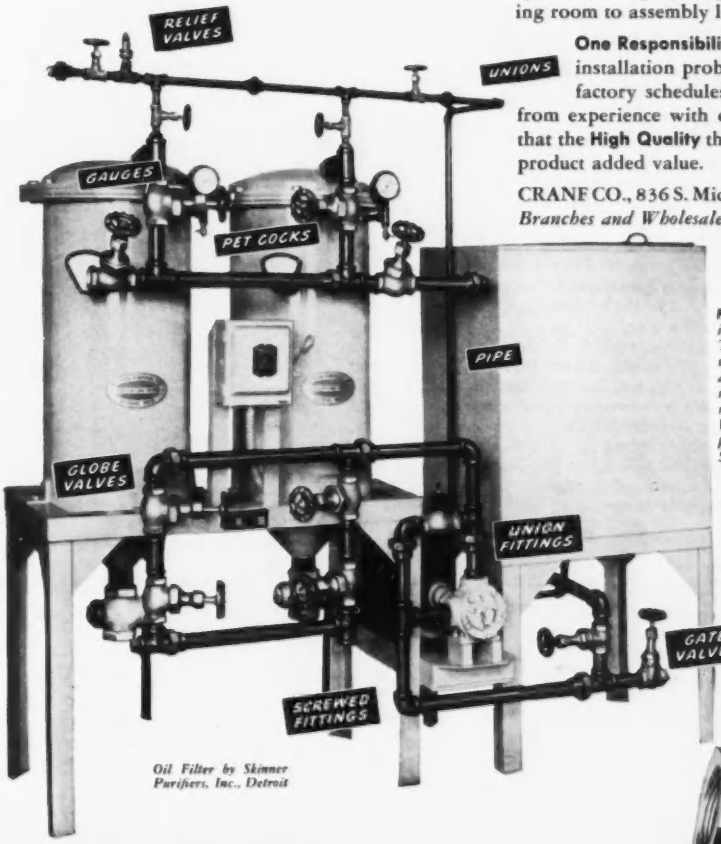
ONE
SOURCE OF SUPPLY
RESPONSIBILITY
STANDARD OF QUALITY

Why spend time hunting for piping equipment when you can get everything from Crane? One catalog . . . well organized for quick, easy reference . . . gives you a comprehensive selection from the world's most complete line of brass, iron, steel and alloy piping materials.

Take this Oil Filter, for example. All valves and fittings, pipe and pipe line accessories are from Crane. And regardless of the design on your boards, specifying Crane as your **Single Source of Supply** helps to speed and simplify all piping procedures, from drafting room to assembly lines.

One Responsibility for materials helps smooth installation problems, assures better control of factory schedules. And your customers know from experience with other Crane piping they buy, that the **High Quality** that is Crane Quality gives your product added value.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Illinois
Branches and Wholesalers Serving All Industrial Areas



Oil Filter by Skinner Purifiers, Inc., Detroit

FOR THROTTLING *and other severe services—Crane recommends No. 14½P Plug Type Disc Brass Globe Valves. Extra wide seating surfaces offer higher resistance to wire drawing; tapered disc permits easy regulation of flow. Seating materials: Crane Nickel Alloy to Exelloy. Working pressures: 150 pounds steam; 300 pounds cold water, oil or gas, non-shock. Sizes up to 3 in. See your Crane Catalog, page 31.*

EVERYTHING FROM . . .

VALVES · FITTINGS
PIPE · PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

Safety Relief Valve Has Large Capacity, Simple Design

A valve of large capacity, Btu rated, and built to conform with current ASME Boiler Code, this new relief valve has been designed for hot water heating boilers. The discharge capacity is 242,900 Btu per hr, sufficient for use with more than 79 percent of all hot water heating boilers. The set opening pressure of this No. 33 safety relief valve is 30 psi. Tappings are: Inlet, $\frac{3}{4}$ in. I.P.S.; Outlet, 1 in. I.P.S. It operates as follows: (1) When the set pressure of 30 lb is reached needle lifts far enough to discharge water at low rate. (2) If temperature rises into emergency zone, increased velocity acts on a ring, which greatly increases lifting power and snaps the valve wide open to dissipate heat at the high rate of 242,900 Btu per hour.

McDonnell & Miller, Inc., Wrigley Bldg., Chicago 11, Ill.

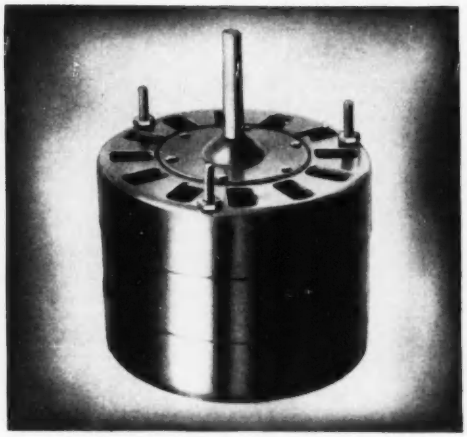
Fasco Industries Announces New Shaded Pole FHP Motor

This new six-pole, shaded pole motor is being made in two lengths and with an outside dia of 5 inches. Power ratings range from $\frac{1}{8}$ to 1/30 hp at speeds from 1,000 to 1,050 rpm when operated at rated voltages. Speed reductions down to 500 rpm are possible by the use of choke control coils.

With a $\frac{3}{8}$ in. dia shaft extension as standard, the motor is available either for stud mounting from end-cases or resilient base mounting. Either open or enclosed housings can be supplied to meet rating and ventilation requirements. Designs are available for horizontal or vertical operation.

Fans, ventilators and other motor driven air movers are typical installation applications of this new motor. It features a 30 percent efficiency, silent operation, and large bearings and oil reservoirs for long, dependable operating life.

Fasco Industries, Inc., Rochester, N. Y.



Throttling Device Reduces Pulsations of Gage Pointer

Using a cartridge made of compressed powdered stainless steel, this snubber is a simple and effective throttling device for pressure gages to reduce or eliminate pulsation of the gate pointer. No adjustments are needed, specific porosity of cartridge for the particular application required makes it effective for air, gas, water, steam or oil for pressures up to 10,000 psi. Cartridges may be easily removed and cleaned, if necessary, or may be replaced. The thousands of minute particles of stainless steel give considerably less chance of clogging than the conventional snubber with a single small hole. The steel body of the snubber is $1\frac{3}{8}$ in. long.

American Chain & Cable Company, Inc., Helicoid Gage Division, Bridgeport 2, Conn.

Small Blower Cools Electronic Equipment

Designed primarily to cool electronic equipment, this blower can be used to ventilate any enclosed area within its size range. It has the following specifications:

Model	805-F Axial Flow Blower
Size	4⅝ in. in dia, and 3¼ in. deep
Weight	28 ounces
Voltage	115, ac, 50/60 cycles
Current	20 amps
Input	19.5 watts
Power Factor	85 percent
Condenser	0.84 to 0.94 mfd, 350 v, ac
Speed	3,599 rpm at 60 cps, and 2,999 rpm at 50 cps.
Free Air Delivery	216 cfm at 60 cps and 180 cfm at 50 cps

Fairchild Camera & Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y.

END

Reach

HIGHER PERFORMANCE LEVELS *with Your Product!*

...by specifying this NEW NORGREN DIAPHRAGM TYPE RELIEF VALVE

1 Automatically prevents damage to equipment through built-up pressures in air and fluid lines.

2 Holds its Relief Pressure setting.

3 Large, exposed diaphragm area provides more positive valve action for large flow at low pressure rise.

4 Metal-to-Metal Valve Seat for pressures up to 250 p.s.i. and more rugged service. Streamlined profile provides better flow conditions and withstands shock loads for longer life.

5 Also available with Rubber-to-Metal Seat for high sensitivity and positive seating with pressures up to 125 p.s.i.

6 Six pipe sizes from ⅛" to 1".

7 Easy installation—straight through pipe connections. Simple maintenance—quickly dismantled without removing from the line.

C. A. Norgren Co., 222 Santa Fe Drive, Denver 9, Colorado

Other Norgren RELIEF VALVES

...for a wide range of requirements!

Diaphragm Type for Hot Water and Air Tanks—No. 466. Pressure ranges 2-15, 15-50, 40-75, 75-125, 125-250, and 5-125 p.s.i. Brass and bronze construction. ¾" inlet, ½" outlet.

Water Relief Valve—No. 475. Two pressure ranges, 0 to 125 and 125 to 175 p.s.i. Full floating, stick-proof valve. Rust proof parts. ½" and ¾".

General Purpose, Low-Flow Valve—No. 61A2. Small, inexpensive, low capacity relief valve for many purposes. Pressure ranges 5-75, 75-150, and 150-250 p.s.i. ¼" only.

Norgren

Lubricators, Regulators, Filters, Valves, Other Air Controls, Hose assemblies.

WARD LEONARD
RELAYS

NEW—
a Mighty Midget Built for Millions of Operations

semi-knife-edge bearing reduces frictional wear

This is Ward Leonard's new Bulletin 110 Midget Relay for long, trouble-free service, particularly in equipments subject to vibration.

Exceptionally good vibration characteristics are due to proper proportioning of contact masses and springing combined with heavy pressures on both normally open and normally closed contacts.

Higher contact ratings than most midgets. Available up to 3-pole, double throw. Contact finger leads are insulated with the new, impregnated glass-fiber tubing.

Write for Bulletin 110. Ward Leonard Electric Co., 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

WARD LEONARD
ELECTRIC COMPANY
Result-Engineered Controls
RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES

OUR READERS SAY

On the Theory of Beam Flexure

To the Editor:

I am enclosing a brief original manuscript which I hope will eliminate a weakness of long standing in elementary flexure theory...

—Frederick L. Ryder
Lynbrook, N. Y.

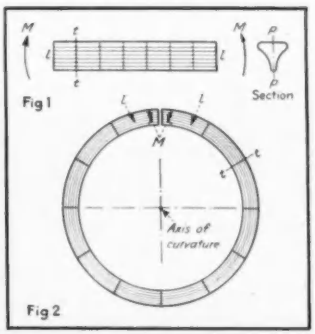
Ed—We are printing Mr. Frederick L. Ryder's article in full. Does anyone want to argue with him about it?

An Improvement in the Presentation of Beam Flexure

In the usual elementary derivation of the flexural relationships in a transversely loaded beam, the basic assumption is made that, for beams of constant applied moment, plane sections normal to the longitudinal axis remain plane after bending. This assumption weakens the argument unnecessarily, for it can be shown that the assumed condition must be true.

Consider the beam of Fig. 1, subjected to the constant moment M. We make the usual stipulations that the material is homogeneous and the cross-section uniform, and that there is no buckling of any kind. We further require that the cross-section be symmetrical about the plane of loading *p-p*, so that there is no tendency for movement out of this plane. Now map all portions of the beam in the unloaded condition by transverse planes *t-t* and longitudinal planes *l-l* normal to the plane of loading.

Next, imagine that the beam, now loaded, is long enough so that the ends just touch, the end moments *M*



still being applied by some hypothetical agency, as in Fig. 2. Consider a longitudinal element in one of the *l-l* planes at a constant distance from plane *p-p*. Since conditions are identical at all cross-sections, the curvature of such an element must be constant, so that it describes a circle in a plane parallel to *p-p*. By symmetry, the center of all such circles must lie on the same line normal to *p-p*, so that this line may be called the axis of curvature of the beam. As for the transverse planes *t-t*, they must remain planar after loading, since they must be exactly radial to the axis of curvature, by symmetry.

These results are unchanged if any portion of the beam is cut out, the end moments still being applied. Further, they are independent of the state of stress in the beam, so long as the material is homogeneous. It is not necessary that Hooke's law be obeyed. It is, however, necessary to assume that M is applied by means of stresses identical to those at sections well removed from the end sections.

The remainder of the derivation can proceed in the conventional manner. Note that we have not proved that all the elements of each *l-l* plane are at the same radial distance from the axis of curvature, so that this must still be assumed. In fact, the customary elementary derivation to hold it is necessary to assume that the effect on the longitudinal stresses and strains of all other stresses and strains is negligible. This assumption is known to be invalid in the case of wide, shallow beams such as flat plates, which are stiffer than is indicated by the elementary theory.

Not Micro, But Micromicro

To the Editor:

We have noted with great interest the article: "Modified SR-4 Indicator To Measure Dynamic Strains," by B. B. Hamner and H Sommer, PRODUCT ENGINEERING, September 1949.

It is likely that we will sooner or later adopt this method in our work, and I started some calculations. But here is where the trouble comes in. The authors' formula

$$f_n = \frac{1}{2\pi R_1 C_1}$$

leads to $R_1 = 0.126$ ohms, when the values $f_n = 1{,}890$ cps and $C_1 = 670$ microfarad arc used as per text. The value of R_1 is then calculated as 0.063 ohms. These resistance values are impractical as they are far too small. It appears that the capacitance should have been stated as 670 micromicrofarad. This would lead to $R_1 =$

because the shape is elliptical

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Write for Bulletin 23. WARD LEONARD ELECTRIC COMPANY, 63 South Street, Mount Vernon, N. Y. Offices in principal cities of U. S. and Canada.

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126,000 ohms and $R_a = 63{,}000$ ohms. Such values would be much more reasonable. That it was probably this error which occurred is borne out by the fact that the authors mention a 365 microfarad variable airgap capacitor. Such capacitors are in the micromicrofarad range.

It appears to be a very good idea to state all results, if numerical examples are given. If, in this article, the resulting R_i value had been mentioned, it would have been obvious that the 670 microfarad is a misprint. The way it is now, one could not detect it offhand, as 670 microfarad could be assembled readily for electrolytic capacitors for such a low voltage. J. H. MEIER
Bucyrus-Erie Co.

Ed.—Thanks for catching our mistake. The original version from the authors' was right, but we missed a typographical error in our proofreading.

Ductile Cast Iron

To the Editor:

We were very much interested in an article in your July, 1949, issue under "Technical News" relating to ductile cast iron.

Kindly advise what firm handles the patent and to whom should we apply for a license to manufacture this type of iron. Also, we would appreciate information such as: can this iron be handled in an ordinary coke-fired iron cupola, and can it be used for the same purposes as cast steel? G. FURLONG
Corner Brook Foundry & Machine Co. Ltd.

Ed.—We suggest you write to Mr. D. J. Reese at the International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y., for licensing agreement details and other specific information.

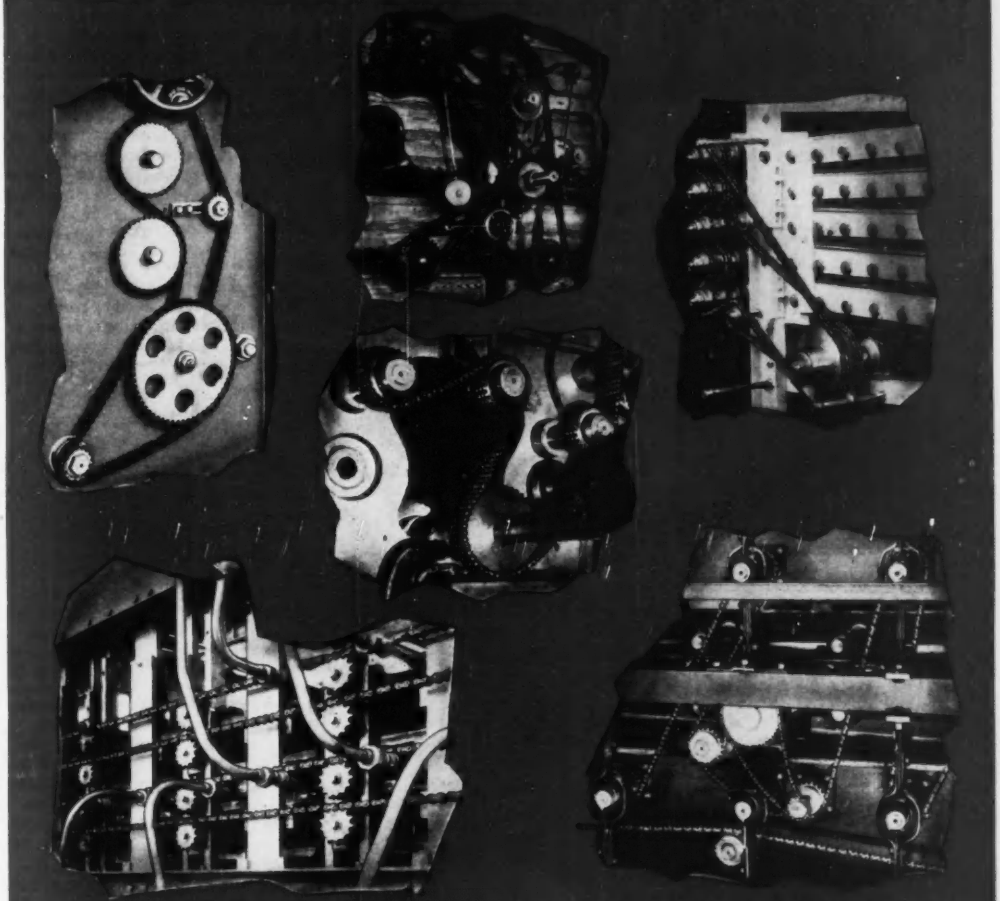
And the Aircraft Industry Isn't Alone

To the Editor:

Please send me three reprints of John Van Hamersveld's article "Design Cost Control" (PRODUCT ENGINEERING, September 1949). I will be glad to defray any costs.

The theory behind this article is just what I have been saying for twelve years as an engineer in the aircraft business, but my talking has been in vain. John Van Hamerveld should be congratulated on his well formulated plan, but even more so should he be commended on the much greater task of getting this program adopted

DRIVING MANY SHAFTS FROM ONE SOURCE



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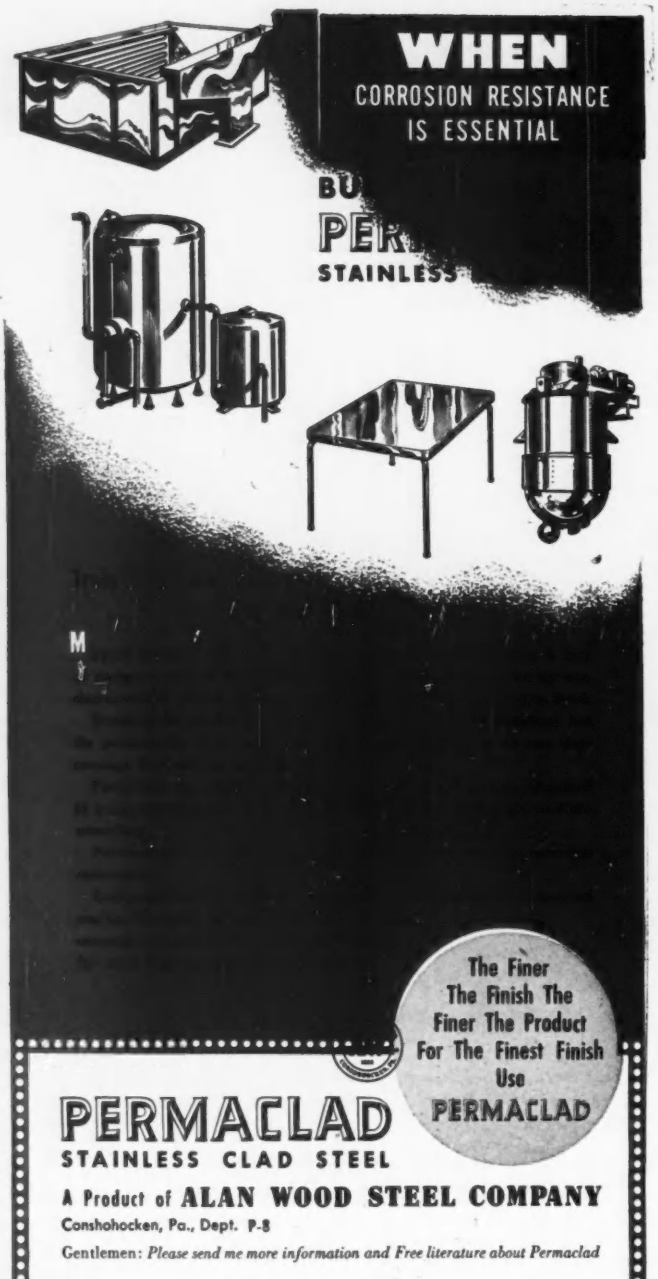
DIAMOND ROLLER CHAINS



in the aircraft industry, antagonistic as it is to all forms of efficiency or change in time honored methods.

Let us have more articles pertaining to the aircraft industry. This is the branch of engineering that has had outstanding success with its products from the standpoint of performance, but from this standpoint alone, for it maintains the most inefficient and wasteful plants in the country, a situation that must be corrected if we are to maintain an adequate air force with the funds available.

—W. A. S. DOUGLAS
Torrance, Calif.

Ed.—Thanks for those kind words about Mr. Hamerveld's article. Of course the aircraft industry is just one example of an industry needing design cost control.

Where Can I Get It?

Small Pitch Conveyor Chain

To the Editor:

Please advise possible source of small pitch conveyor chain described on page 117 of your March issue.

—HARRIS BROWN
E. I. du Pont de Nemours & Co.

Ed.—Here are some possible sources: Diamond Chain and Mfg. Co., 40 Kentucky Ave., Indianapolis, Ind.; Baldwin-Duckworth Div. of Chain Belt Co., 375 Plainfield St., Springfield 2, Mass.; The Whitney Chain & Mfg. Co., 237 Whitney St., Hartford 2, Conn.; Link Belt Co., 220 S. Belmont Ave., Indianapolis, Ind.; Morse Chain Co., 50 Church St., New York City; and the General Chain & Belt Co., 276 Lafayette St., New York.

Ceramic Extrusion

To the Editor:

In the July 1947 issue of PRODUCT ENGINEERING there appeared, on page 131, an abstract entitled "Designing Small Ceramic Part," by J. Wallich. In that paper reference is made to the extrusion of ceramics. I am interested in learning more about the art of extrusion and would appreciate any references that you could send me on this subject. I wonder also, if you would be able to supply me with the names of manufacturers of laboratory extrusion units for ceramics?

—LEO J. CRONIN
Raytheon Mfg. Co.

Ed.—Glad to see that you keep Product Engineering on file for over

FAST'S COUPLINGS STOP UNNECESSARY SHUTDOWNS IN *Your* PLANT

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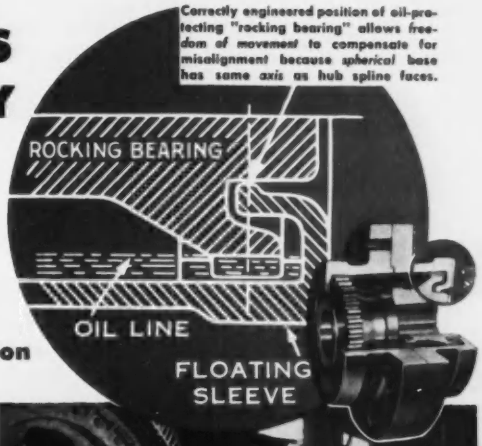
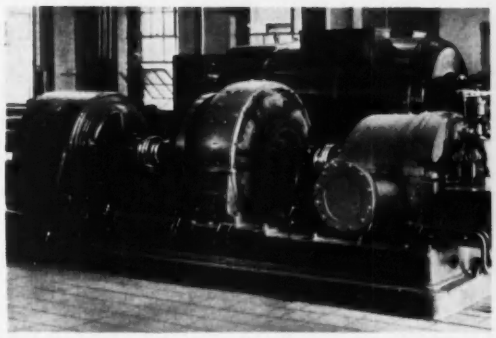

Correctly engineered position of oil-protecting "rocking bearing" allows freedom of movement to compensate for misalignment because spherical base has same axis as hub spline faces.
ROCKING BEARING
OIL LINE
FLOATING SLEEVE



POWER PLANTS use Fast's Couplings because metal-to-metal seal, absence of perishable parts, virtually eliminate shutdowns!

STEEL MILLS specify Fast's Couplings for equipment of every shaft size to avoid production shutdowns caused by *failure* of ordinary couplings! This Coupling has been in use since 1923!

FAST'S Couplings virtually eliminate plant shutdowns because Fast's exclusive metal-to-metal seal gives positive protection, provides uninterrupted power transmission! Complete flexibility to compensate for shaft misalignment is done mechanically. Load-carrying oil is *completely* guarded by exclusive "rocking bearing" that keeps out dirt, grit and moisture without perishable packing rings! Nothing to wear! Nothing to replace! Result: Uninterrupted power transmission for all your installations!

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Compensate for all Misalignment

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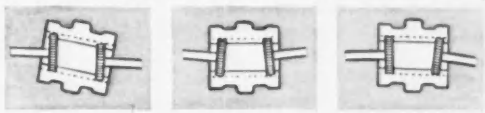
The exaggerated diagrams below demonstrate this Fast's principle



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two years, Mr. Cronin. Here are some references to ceramic extrusion:

"A propos de l'etirage normal et de l'etirage sous vide", Industrie Ceramique, #376, pp. 218-25 (July, 1947): "Symposium on Normal and Vacuum Extrusion of Clay", J. Lucas, "De-airing of Clay

H. R. Straight, "Measuring Cumulative Power of Plasticizing and Extruding Stiff Mud Shapes", American Ceramic Society Bulletin, Vol. 20, #21, pp 48-50 (Feb. 1941)

J. C. Everhart, "Extruding Refractories," Brick and Clay Record, Vol. 112, p 70, (June, 1948)

H. H. Hausner and A. F. Naporan, "Shrinkage of Extruded Steatite Tubes", American Ceramic Society Bulletin, Vol. 24, pp 246-50 (July 15, 1945)

S. H. Stupakoff, "Extruding Press for Ceramic Mixes," U. S. Patent 2,364,566, December 5, 1944, (to Stupakoff Ceramic & Mfg. Co.).

As for the manufacturer of a laboratory extrusion unit for ceramics, we suggest that you contact the International Clay Machinery Co. in Dayton, Ohio. They make a small unit for extruding ceramic parts, called the "Vac-aire".

Walkie-Talkies

To the Editor:

In your Feburary, 1949, issue you devote an article to Civilian Walkie-Talkies, made by Citizens Radio Corporation. We are greatly interested in securing further information about this product but do not have the company address. We would sincerely appreciate your sending us their address.

LOWELL H. ERICKSON
Merrill Engineering Laboratories

Ed.—These Walkie-Talkies are made by the Citizens Radio Corporation, located at 1865-71 Prospect Avenue, Cleveland 15, Ohio.

How Do You Bend a Pipe?

To the Editor:

I am interested in obtaining information on the bending of aluminum and copper pipe in diameters greater than 2 inches. Have you issued any reports of articles on this subject?

—HAROLD H. RUDD
Greensburg, Pa.

Ed.—You should be able to get a very complete answer to your problem from Mr. E. J. DeWitt, vice president and general manager of The Wallace Supplies Mfg. Co. at 1308 Diversey Parkway, Chicago 14, Ill. Mr. De Witt has written extensively

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FOR POWER TRANSMISSION REQUIRE NO MAINTENANCE

Patented Flexible Disc Rings of special steel transmit the power and provide for misalignment and end float.

Thomas Couplings have a wide range of speeds, horsepower and shaft sizes:
½ to 40,000 HP
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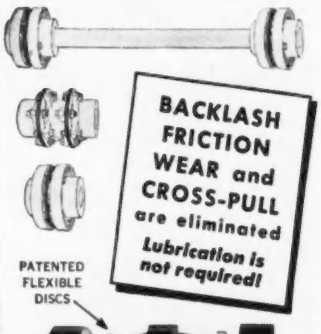
Specialists on Couplings for more than 30 years



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ALL PARTS ARE SOLIDLY BOLTED TOGETHER.

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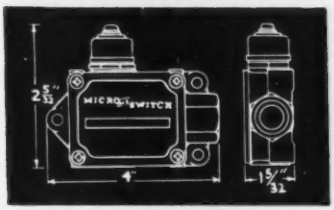
2 MICRO Precision Switches...

1. MICRO BAFI-2RN2 precision switch with adjustable roller arm actuator.

2. MICRO BAFI-2RN precision switch with plunger actuator. Both switches are available in both right and left hand designs.



Combining High Electrical Rating with High Inrush Capacity

These two MICRO precision switches offer the design engineer the answer to applications which call for a steady state current rating of 20 amperes and an inrush capacity of 75 amperes at voltages up to 460 volts a-c.

Available with both plunger and adjustable roller arm actuators, these switches are sealed in rugged die cast aluminum housings to protect against mechanical damage or shock. Overtravel mechanism is built into the metal housing. Ample wiring space is provided in the housing. Side facing terminals on the enclosed basic switch simplify wiring.

Underwriters' Laboratories list these two switches for ¾ H.P., 115 volts a-c; 1½ H.P., 230 volts a-c; 20 amperes, 125, 250 or 460 volts a-c; tungsten lamp, 10 amperes, 125 volts, a-c.

These two switches are typical of MICRO'S continual effort to develop new precision switches to meet every type of design requirement. They are but two of more than 3900 varieties of MICRO precision switches. Whatever your design problem, if it involves the use of precision snap-action switches, consult MICRO SWITCH engineering service direct or contact any of the offices listed. It may save you time and money.

MICRO ... first name in precision switches

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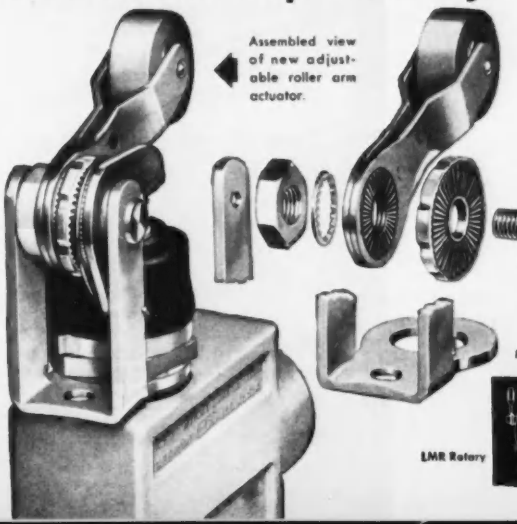
New MICRO Improved Adjustable Roller Arm Actuator

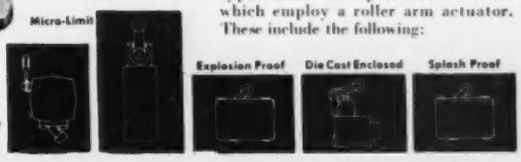


Assembled view of new adjustable roller arm actuator.

The MICRO BAFI-2RN2 precision switch shown above and all of the wide variety of MICRO roller arm operated switches are now equipped with this new positive lock device. The serrations on the roller arm (see exploded view) make possible a positive lock of the roller arm in increments of approximately .2°.

Exploded view of new adjustable roller arm actuator showing serrations which give positive-lock in all positions.

Variations of this new adjustable roller arm actuator are now standard on all types of MICRO precision switches which employ a roller arm actuator. These include the following:



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Competition is returning. Up-to-date engineering can be *important to you!*

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NEW 1½" NOW AVAILABLE

Now in production for ¼", ⅜", ½", ¾", 1" and 1½" shaft diameters. If you have a catalog, phone your representative or write us for new Data Sheet. If not, write for complete literature and the name of our representative in your city.

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PROGRESSIVE MANUFACTURERS USE BALL BUSHINGS — A MAJOR IMPROVEMENT AT A MINOR COST

on the subject of pipe bending, giving proper bending radii, etc., and we believe that he now has a new book in preparation.

Ceramic-Metal Alloys

To the Editor:

In your July, 1949, issue you published an article on Ceramic-Metal Alloy.

We are very much interested in this and would like very much to find out the source of manufacture so that we could secure more details and information on same.

—H. R. FORTEN
V. P., Greenback Industries, Inc.

Ed.—The full name of the article was "Ceramic Metal Alloy Has Thermal Shock Resistance Needed for Turbine Blades."

For further information write the National Advisory Committee for Aeronautics, 1724 F Street, N. W., Washington 25, D. C.

Protection For Machine Parts

To the Editor:

In the January, 1949, issue of PRODUCT ENGINEERING we have been interested in an article by Watson G. Harding on "Protecting Machine Parts with Dust Excluder Boots."

The components mentioned in this article seem to fulfill conditions which we have frequently met in the past, namely the provision of compact, long extension gaiters. We shall be interested, therefore, if you can tell us the name of the manufacturer in the United States, as we wish to get in touch with them to find out their associates or licensees in this country, if any.

R. W. BUCKLER
Exactor Control Company Ltd., England

Ed.—Further information regarding the components mentioned in the article by Watson G. Harding may be obtained by contacting Mr. Watson G. Harding, Multi-Flex Products, United States Rubber Co., Passaic, N. J.

Patent Drawing Information

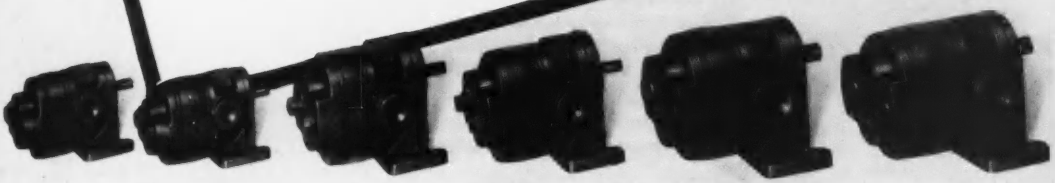
To the Editor:

Can you advise a good source of patent office drawing procedure?

—JAMES BRANNON
St. Paul, Minn.

Ed.—One source is a Department of Commerce publication, *Rules of Practice In Patent Cases*, obtainable for 40 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

Wide range... right selection...



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OUTSTANDING FEATURES

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- Distinctive design mechanical seal requires no adjustment.
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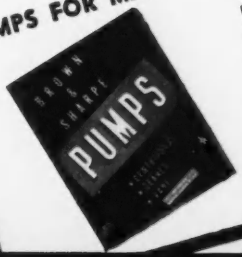
PUMPS FOR MANY APPLICATIONS



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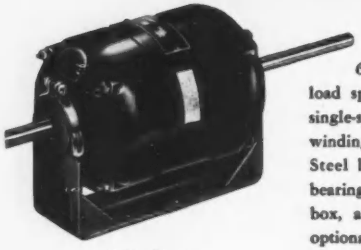


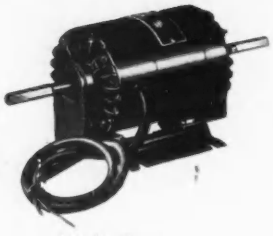
5" dia. Frame

Type 470

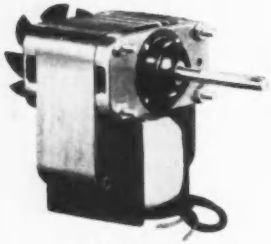
6-pole, 1/8 to 1/15 H.P., maximum load speed 1050 r.p.m. furnished with single-speed, two or three-speed tapped windings, for fan or blower operation. Steel backed babbitt bearings. Ball-bearings, resilient mounting, conduit box, and thermal overload protection optional features. Bulletin 4000.

Type 330

4-pole, 1/10 to 1/50 H.P., 1550 r.p.m. Die Cast frame with sleeve or ball bearings. Drawn steel frame with self-aligning sleeve bearings only. Resilient base and thermal overload protection optional. Write for data. Bulletin in course of preparation.



3⅜" dia. Frame



3½" square Frame

Type 350

2-pole 1/6 to 1/40 H.P., 3000 r.p.m. With or without gear reducers. Can often be substituted for more expensive motor types permitting a new low cost approach to motorizing equipment intended for mass markets. Sleeve or ball bearings. Skeleton frame only. Very quiet. Bulletin 2000.

Type 230

2-pole 1/50 to 1/200 H.P., 3000 r.p.m. 3 Models: *Deluxe*, with die cast bearing brackets, reoilable reservoirs, maximum quietness for sound reproduction apparatus in particular; *Economy*, with brass bearing brackets for lowest cost, high output for fans, blowers, etc.; *Electric Heater*, with special insulation features to pass Underwriters' Laboratories tests on radiant heating devices such as bathroom heaters, hair dryers, etc. Bulletin 1000.

2⅜" square Frame

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Division of Raytheon Mfg. Co.

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MEETINGS

November 2-4

AMERICAN SOCIETY OF BODY ENGINEERS—Fourth Annual Technical Convention; Rackham Memorial Building, Detroit, Mich.

November 7-8

SEVENTH ANNUAL CONFERENCE ON X-RAY AND ELECTRON DIFFRACTION—Mellon Institute of Industrial Research, Pittsburgh, Pa.

November 10

AMERICAN IRON AND STEEL INSTITUTE—Regional Technical Meeting; Mark Hopkins Hotel, San Francisco, Calif.

November 10-11

FOURTH MIDWEST QUALITY CONTROL CONFERENCE—Jefferson Hotel, St. Louis, Mo.

November 14-18.

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION—Twenty-third Annual Meeting; Haddon Hall, Atlantic City, N. J.

November 20-December 3

TWENTY-SECOND EXPOSITION OF CHEMICAL INDUSTRIES—Grand Central Palace, New York City.

November 27-December 2

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Annual Meeting; Hotel Statler, New York City.

November 30-December 2

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS — Annual Meeting; Hotel New Yorker, New York City.

December 9-10

INSTITUTE OF RADIO ENGINEERS—Southwestern Conference; Baker Hotel, Dallas, Texas.

December 26-31

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—116th Annual Meeting, New York City.

January 9-13, 1950

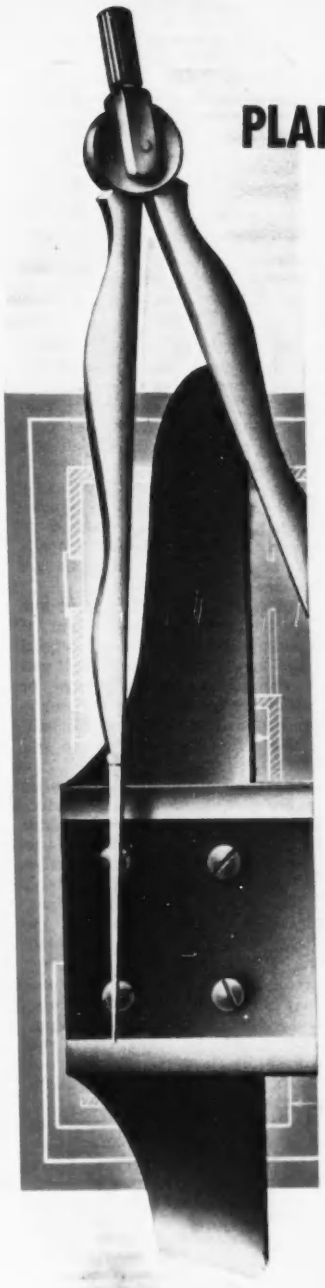
SOCIETY OF AUTOMOTIVE ENGINEERS—Annual Meeting and Engineering Display; Book-Cadillac Hotel, Detroit, Mich.

January 23-26, 1950

INSTITUTE OF AERONAUTICAL SCIENCES—Eighteenth Annual Meeting; Hotel Astor, New York City.

January 30-February 3, 1950

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—Winter General Meeting, New York City.



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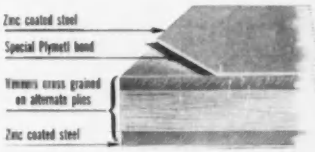
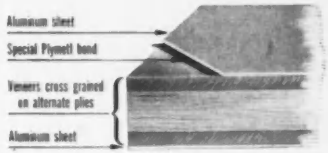
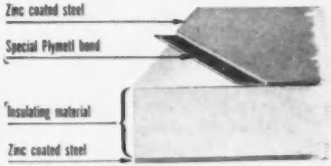


PLYMETL VU and UVU — A plywood plaque with aluminum sheet permanently bonded to one (VU) or both faces (UVU). The great strength and light weight factors of plywood are combined with the light weight of aluminum. Plymetl may be formed to certain curvatures.



PLYMETL ESE — A panel of insulating material with metal sheet permanently bonded to both faces (ESE).

Other types of core materials may be used to make varied kinds of Plymetl. To these cores, metal faces of monel metal, porcelain enamel steel, and stainless steel can be bonded. A core material may be faced with one type of metal on one side and another type on the other side. On all Plymetl panels, the metal faces provide an ideal surface for finishing.



Write for complete data on Plymetl, and bulletin SC45 which gives details on other types of Haskelite materials. Let Plymetl and Haskelite engineers help you design and build products that look better . . . sell better . . . and perform better.

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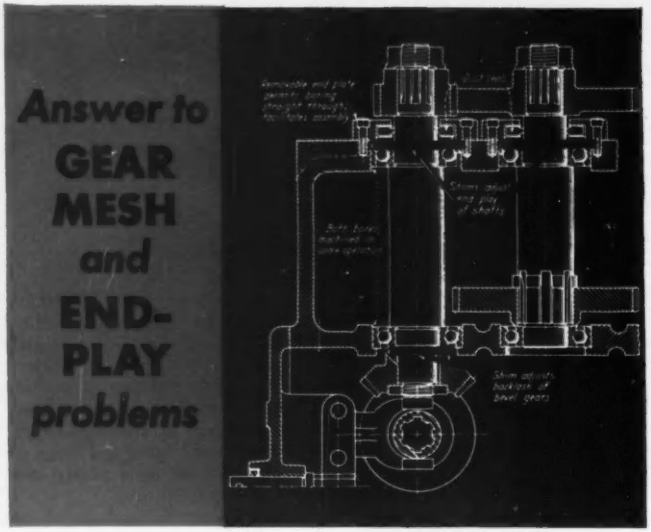

IF YOU'RE WASTING TIME AND TYING UP A STANDBY LATHE . . .

Laminated shims can stop the expensive process of assembly, testing, disassembly, machining a few thousandths, reassembly, retesting and so on for many costly hours.

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NEW BOOKS

Titanium
Its Occurrence, Chemistry, and Technology

JELKS BARKSDALE, *Ph. D., Alabama Polytechnic Institute. 591 pages, 6 x 9 in. Published by the Ronald Press Co., 15 E. 26 St., New York, N. Y.* $10.

As a reference book for chemists and metallurgists working on the production of pure titanium, titanium dioxide, or ferrous or non-ferrous materials in which titanium is used as an alloying element, Dr. Barkdale's book may be a valuable aid. As a primer on the effect of titanium on pigments, on materials for the electrical and ceramic industry, and on certain chemical reactions, it probably will fill the bill. On these aspects, we really are not qualified to judge.

But as an aid to the designer who may be interested in the use of titanium metal as a structural material —and some observers feel that it will be competitive with aluminum or stainless steel within 5 to 10 years— Dr. Barksdale has fumbled the ball In this respect, however, he can still make a fast recovery.

About half of the present volume is devoted to the occurrence and production of titanium ores, to the chemistry of titanium and titanium salts, and to other chemical problems in reduction of the ore. The other half of the book is given over to specific applications, and to the chemical processes involved: Process of Pigment Manufacture; Titanium Pigment Industry; Uses of Titanium Pigments; Iron and Steel; Nonferrous Metals and Alloys; Hard Alloys; Electrical Industry; Ceramics; Mordants and Dyes; and Catalysis. In short, the book is aimed primarily at the chemist and the chemical engineer.

There is probably a good reason for the omission of details information on titanium metal and alloys. When Dr. Barksdale's book went to press, many of the properties both physical and mechanical, had not been established; many—particularly of various alloys of titanium—still have not been. For that reason, a second volume could well be undertaken. By the time that it became ready for distribution, the science will have progressed to the point that much of the data that today is unknown will have been established. Such information as the composition

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Enemy ***number one*** of electric motors is overload—excessive current that causes motor windings to overheat, burn out. Here is an enemy of ***all*** motors, small or large, ready to go into action immediately a motor starts. Devices for protecting electric motors against overload, therefore, must be exceptionally dependable . . . must not fail to disconnect the motor from the line before a dangerous temperature is reached.

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In controls of this type, the current that flows through the motor windings is used to heat Nichrome thermal elements in the overload relays. Thus heating of the relay element monitors the heating of the motor windings. When a dangerous motor temperature is reached, the heat from the Nichrome unit releases a contact arm in the relay, thereby disconnecting the motor from the line. Given a few seconds to cool, the relay mechanism can be reset by pressing a button—completing the motor circuit again.

STABILITY OF NICHROME ASSURES DEPENDABLE RELAY PERFORMANCE

Because of its uniform quality, superb corrosion-resistance, and retention of physical and electrical properties at high temperatures, Nichrome is unsurpassed for the accurate job the all-important thermal unit must perform in these Allen-Bradley controls.

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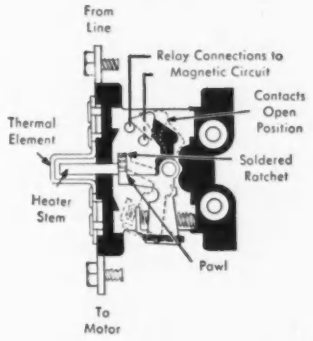
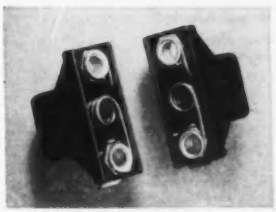
ALLEN-BRADLEY RESISTO-THERM RELAY OPERATION



The heater stem is almost completely surrounded by a Nichrome thermal unit. A ratchet wheel is soldered to one end of the heater stem, and this engages a pawl which holds the relay contacts closed against spring tension. Sustained overload on the motor heats the Nichrome element which, in turn, heats the stem. Heat from the stem melts the solder, which frees the ratchet wheel. The wheel turns and releases the pawl, thereby opening the relay contacts.



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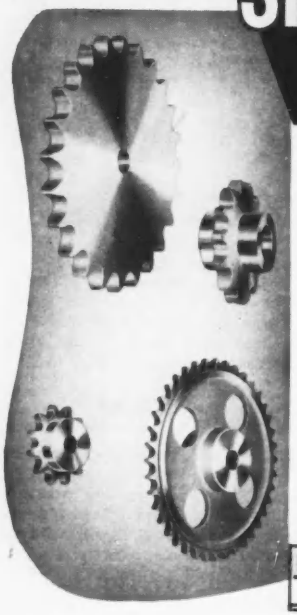

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and properties of recommended alloys; machining, welding, drawing, forging, and extruding of the metal; and detailed application information will be the type of data that design engineers will need, and need in the near future.

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88 PAGES, 8½ x 10. *in. Published by the Lake City Malleable Co.,* 5000 *Lakeside Ave., Cleveland* 14. *Ohio. No charge.*

Written for engineers, designers, teachers and students of engineering, this book gives complete coverage of the physical, chemical, electrical and thermal properties of Malleable castings. A good layout and many colored cartoons make this a very readable and interesting manual. The many humorous illustrations give the book a light touch, but there is no sacrifice of the good meaty information that product engineers must have about any material they deal with.

The book covers grades and uses of Shockproof Malleable, reasons for selection of Shockproof Malleable, users' specifications, users' finishing operations, relationship of users, questions and answers, and specialties.

There is a complete appendix, glossary, bibliography and index.

To obtain this book write the Lake City Malleable Co. at the above address on Company letterhead paper. It should be useful to any product engineer.

University Physics

FRANCIS WESTON SEARS, *Professor of Physics, Massachusetts Institute of Technology and* MARK W. ZEMANSKY, *Professor of Physics, College of the City of New York.* 6¼ x 9¼, 848 *pages. Published by Addison-Wesley Press, Inc., Cambridge* 42, *Mass.* $6.

This text is based on Sears' three volume work, *Principles of Physics.* The material covered includes Mechanics, Heat, Sound, Electricity and Magnetism, Optics, and Atomic Physics. Those topics fall within the scope of intermediate physics have been eliminated and this volume has been planned for a two-semester course. *University Physics* differs from *College Physics* (also based on Sears' *Principles of Physics*) in that the present volume makes use of calculus to a limited degree. It is intended for students of science and engineering who are taking a course in calculus concurrently and to whom calculus is still a new tool. Starting with Chapter 4, calculus is used sparingly and simply in the body of the text and in a

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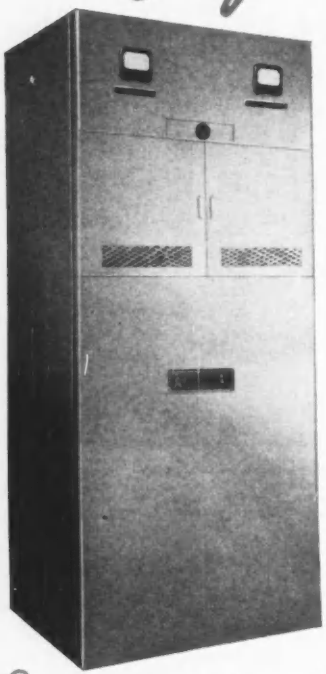

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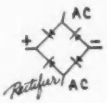

Starting contactor, voltage and current controls, transformer, filter components, rectifier, meters and protective devices—all components necessary for battery charging and control are contained in the heavy sheet metal cabinet of the PECo Battery Charger . . . Compact design eliminates the necessity of installing separate starter and control panel and the interconnection of power and control circuits . . . AC input and DC output leads may be brought in from the top, simplifying conduit installation . . . There are no moving parts . . . No fans or other ventilating equipment required . . . No special foundations necessary.

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few of the problems at the end of each chapter.

The emphasis is on physical principles. Historical background and practical applications have been given a place of secondary importance.

Three systems of units are used: the English gravitational system because it is the one used in engineering work throughout the country; the cgs system because some familiarity with it is essential for any intelligent reading of the literature of physics; and the mks system because of its increasing use in electricity and magnetism, as well as because it seems destined eventually to supplant the cgs system. In the subjects of Electricity and Magnetism rationalized mks units are used exclusively.

Metallurgy and Magnetism

JAMES K. STANLEY, *Research Metallurgist, Magnetic Department, Westinghouse Research Laboratories.* 6x9 *in.,* 156 *pages. Published by the American Society for Metals, Cleveland, Ohio.* $4.

This book is based on a series of three educational lectures on metallurgy and magnetism presented to members of the American Society for Metals during the 30th Annual Metal Congress and Exposition held in Philadelphia, Pa. Too few of the metallurgists today are aware of the importance of magnetic materials in our engineering scheme of things. As a group, the metallurgists have neglected the field of magnetic materials. This book is an attempt to fill the gap with much needed information.

The essentials of ferromagnetism are introduced before the metallurgical aspects of magnetic materials are discussed. This discussion goes into atomic theory, in providing a background of fundamental principles and definitions.

Topics covered in this book include theory and properties of magnetic materials, types of magnetic materials, factors affecting magnetic properties, and a discussion of magnetic analysis as a metallurgical tool.

The Principles Of Metallographic Laboratory Practice

GEORGE L. KEHL, *Associate Professor of Metallurgy, Columbia University.* 6¾ x 9¾ *in.,* 520 *pages. Published by the McGraw-Hill Book Co.,* 330 *W. 42nd St., New York* 18, *N. Y.* $5.50.

This new third edition retains the purpose of previous editions in presenting the fundamental principles of

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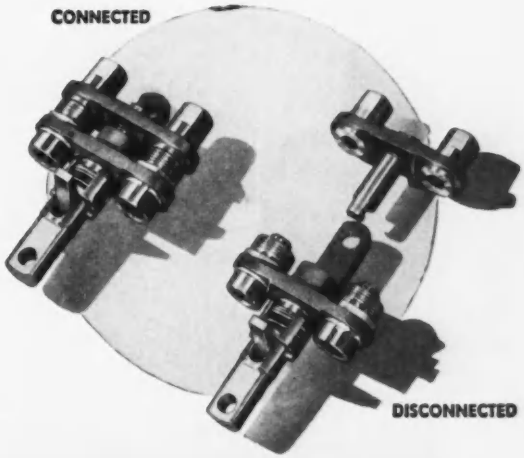

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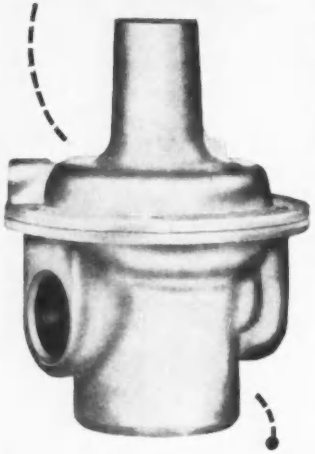

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metallographic laboratory practice in a treatment that bridges the gap between theoretical physical metallurgy and its practical application in the laboratory.

The book has been thoroughly revised and rewritten to include the latest developments in the field. Many new photomicrographs, which are the heart of the book, have been added. Changes in procedures and pedagogical treatments have also been incorporated.

In this revision, the text material has been expanded to describe involved principles more clearly. Latest information on general metallographic laboratory practice, as well as latest techniques and associated laboratory equipment have been added. Test procedures have been revised to conform to the latest specifications established by various technical societies. Tabular data, such as etching reagents, have been expanded and brought up-to-date.

Advanced Calculus For Engineers

F. B. HILDEBRAND, *Assistant Professor of Mathematics, Massachusetts Institute of Technology.* 5¾ x 8½ *in., 594 pages. Published by Prentice-Hall, Inc., 70 Fifth Ave., New York 11, N. Y.* $8.

The purpose of this text is to present an integrated treatment of those topics in mathematics which may be based on a sound working knowledge of elementary calculus, and which are of common importance in a number of fields of application. The text includes the result of a series of revisions of material originally prepared in mimeographed form for use at the Massachusetts Institute of Technology.

An effort has been made to deal with the various topics in a connected way, and hence to bring special methods and topics into logical focus by showing their relationship to one another. At the same time, the author has tried to avoid sacrifice of motivation for mathematical elegance, in order that the important points may be clearly emphasized and not obscured by distracting derivation. In this connection, questions of mathematical rigor in which an engineer has only academic interest are not unduly stressed. Still, in cases where a rigorous proof is omitted, an attempt is made to state the results precisely and, especially, to emphasize limitations which are practically significant. Formal derivations are described as such, and logical defects are explicitly pointed out.

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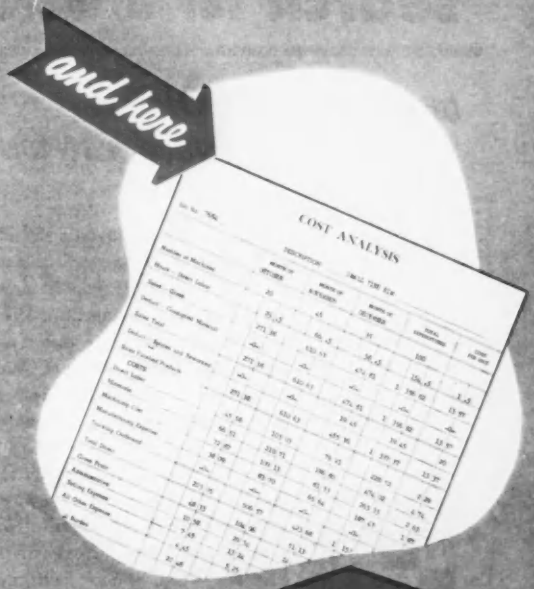

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trated by numerous applications. Care has been taken to choose illustrations which are of interest, at least by analogy, to a wide class of readers. Also, an attempt has been made to avoid overstepping the bounds of a text in mathematics in an effort to teach a particular engineering topic.

The first five chapters are concerned chiefly with ordinary differential equations. In particular, the material of the first chapter can be considered as either a systematic review or an initial introduction to the elementary concepts and techniques, associated with linear ordinary differential equations, which are needed in subsequent chapters.

Chapter 6 develops the useful ideas and tools of vector analysis. Together with Chapter 7, which introduces the basic concepts associated with the simpler types of partial differential equations, it serves also to motivate the treatment of the partial differential equations of mathematical physics which forms the basis of most of Chapter 8. The concluding chapter leads to a knowledge of those topics in the theory of analytic functions of a complex variable which are needed by the engineering student.

Aluminum and Magnesium Design and Fabrication

R. BURT SCHULZE, *Supervisor of Manufacturing Research, The Glenn L. Martin Company.* 589 *pages,* 6 x 9 *in. Published by The McGraw-Hill Book Co., Inc.,* 330 *W.* 42*nd St., New York* 18, *N. Y.* $7.50.

Perhaps no other designers have quite the same problems as the aircraft engineer. The parts he designs may be made only for a few experimental models, they may be needed for a plane in relatively low production, or they may be destined for a model that will be made in large numbers. The details of the design and the method used to fabricate the parts materially affect the cost of the part.

In this book, the author has broken down the various methods of forming aluminum and magnesium into (1) those suitable for experimental production; (2) those recommended for limited production; and (3) those best adapted for mass production. The subject matter therefore is more than a guide to the methods that can be used to make the part; it also is a text in practical manufacturing economics.

Each of the fabricating techniques for different rates of production are further broken down into operations on various types of equipment. A case in point is the section on limited production methods, which consists of

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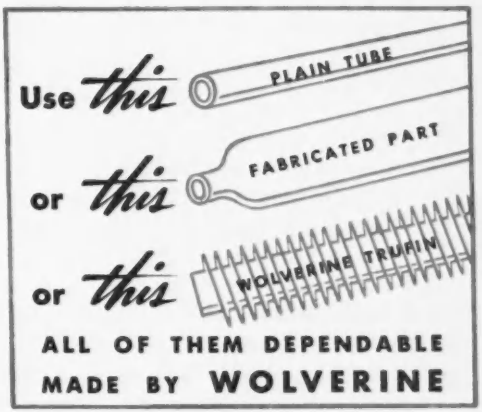

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discussions of forming techniques on the following equipment: Router, shaper, and press brake; rubber hydraulic press; hydraulic press; mechanical press; drop hammer; and contour roll former.

Another large section of the book is devoted to the problem of joining and fastening aluminum and magnesium sheet.

Scientific Autobiography And Other Papers

MAX PLANCK. *Translated from the German by Frank Gaynor.* 187 *pages,* 5½ x 8¼ *in. Published by Philosophical Library,* 15 *East 40th St., New York* 16, *N. Y.* $3.75.

For those who think of physics as being a basic philosophy rather than a pure tool of the engineer, this book will be a revelation and a delight.

Many readers will recognize Max Planck as one of the world's greatest physicists. Many more will remember him as the father of the quantum theory. Beginning at the age of 17, he spent the rest of his long life—almost 90 years—in pursuit of absolute physical truth. This book of essays stands as a memorial to his long life as a great scientist and physicist. They deal with problems which for many decades beset this great thinker, such as: True and Fictitious Issues in Science; Meaning and Limit of Exact Science; Physics and Casuality; Natural Sciences and the Religious world, etc.

In the autobiographical notes, the late physicist tells a fascinating story of his own personal and scientific development. With great simplicity the living mind of one of our most outstanding contemporaries unfolds before our eyes. The reader won't get a course in physics here, but he will better understand the working of a great mind.

Engineering Developments In the Gaseous Diffusion Process

Edited by Manson Benedict, Hydrocarbon Research, Inc. and Clarke Williams, Brookhaven National Laboratory. 129 *pages,* 6¼ x 9¼ *in. Published by the McGraw-Hill Book Co., Inc.,* 330 *W. 42nd St., New York* 18, *N. Y.* $1.25.

This volume is one of a series which has been prepared as a record of the research work done under the Manhattan Project and the Atomic Energy Commission. The name Manhattan Project was assigned by the Corps of Engineers, War Department, to the

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As process development and design of the diffusion plant progressed, it was found that a number of novel auxiliary devices would be needed. This volume describes research and engineering developments undertaken in connection with these auxiliary devices, when they are of sufficient novelty or general interest to warrant inclusion in the National Nuclear Energy Series.

The volume is divided into four parts: Part 1, "Special Plant Instruments and Devices"; Part 2, "Vacuum Engineering"; Part 3, "Development of Heat-Transfer Equipment"; Part 4, "Absorption of UF_6 and Fluorine."

Physical Metallurgy Of Aluminum Alloys

W. L. FINK, F. KELLER, W. E. SICHA, J. A. NOCK, JR., E. H. DIX, JR., *Research Laboratories, Aluminum Company of America.* 247 *pages,* 6x9 *in. Published by the American Society for Metals, Cleveland, Ohio.* $5.

This book is based on a series of five educational lectures on physical metallurgy of aluminum alloys presented to members of the American Society for Metals during the 28th National Metal Congress and Exposition held in Atlantic City, New Jersey.

"Equilibrium Diagrams of Aluminum Alloys" by W. L. Fink, chief of the Physical Metallurgy Division. Topics covered by Mr. Fink include a definition of the equilibrium diagram, designation of the phases, and determination of aluminum alloy and equilibrium diagrams. Discussed under the latter heading were: Preparation of alloys, sampling and analyzing the alloys, obtaining equilibrium, temperature measurement, methods for determining phase fields, thermodynamic relations and interpretation of equilibrium diagrams.

"Metallography of Aluminum Alloys" by F. Keller, chief, Metallography Division. Topics covered by Mr. Keller includes: Etching solutions for revealing the microstructure, preparation of specimens for micro-

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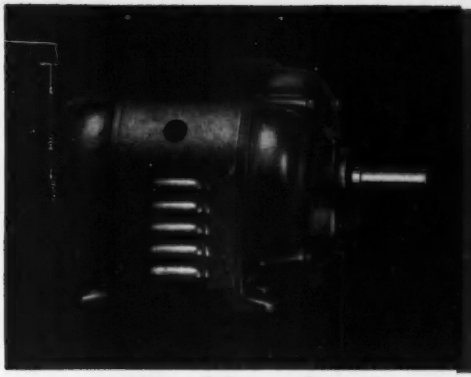

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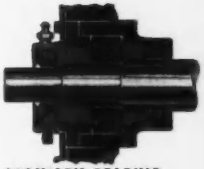

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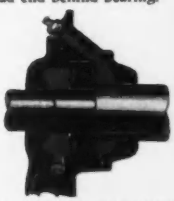

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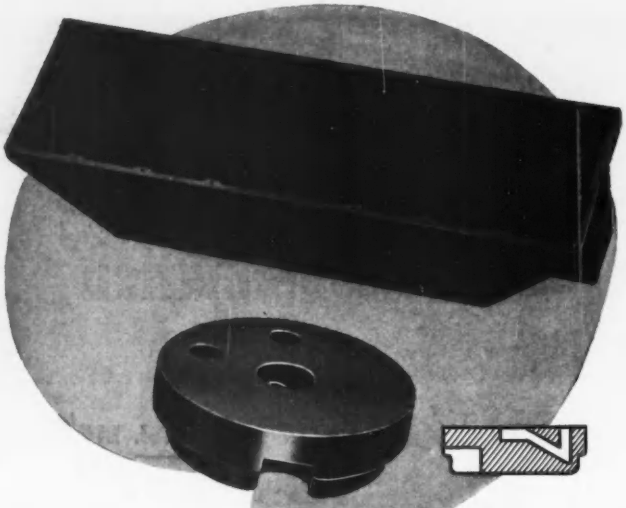

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"Commercial Wrought Aluminum Alloys" by J. A. Nick, Jr., assistant chief, Physical Metallurgy Division. This discussion includes nonheat-treatable alloys, heat-treatable wrought aluminum alloys, alclad products, formability, and resistance to corrosion.

"Thermal Treatment of Aluminum Alloys" by E. H. Dix, Jr., assistant director of Research. This lecture includes a discussion of annealing treatment, recovery treatments, preheating, solution heat treatment, quenching, aging and reheating.

The Principles of Magnaflux

F. B. DOANE, *President, Magnaflux Corp. and* C. E. BETZ, *Vice-President, Magnaflux Corp. Third edition,* 388 *pages,* 6 x 9 *in. Published by Magnaflux Corp.,* 5900 *N. W. Highway, Chicago* 21, *Ill.* $5.

Magnaflux is a name given to a method of nondestructive testing of magnetic materials. A part to be tested by Magnaflux methods is first magnetized. A ferromagnetic material is then applied, either as a dry powder or in liquid suspension. The presence of the magnetic field will then cause the distribution of the ferromagnetic material in a pattern. Irregularities in this pattern indicate the possibility of defects in the material.

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scribe the types of defect which can be detected by Magnaflux tests and the character of the irregularities in the distribution of the ferromagnetic material which can be observed. This is followed by a chapter on the application of Magnaflux testing to welds, large castings and forgings. With the exception of a chapter on demagnetizing a part after it has been subjected to a Magnaflux test, the remainder of the book is devoted to interpretation of Magnaflux test. Included in this discussion is a chapter on nonrelevant or false indications. The final chapter touches upon the problem of deciding whether the defects revealed by Magnaflux tests should lead to the rejection of the part.

Treatise on Powder Metallurgy

(Vol. I, Technology of Metal Powders and Their Products)

CLAUS G. GOETZEL. 778 *pages*, 6¾ x 9¼ *in. Published by Interscience Publishers, Inc., New York.* $15.

This volume deals with the technology of powder metallurgy processes, including a brief description of the underlying principles and a historical review. The production, properties, and testing of powders, as well as their conditioning for powder metallurgy operations, are discussed and a survey of the currently available commercial grades of powders is made. This feature is believed unique—and necessary—for the beginner entering the field.

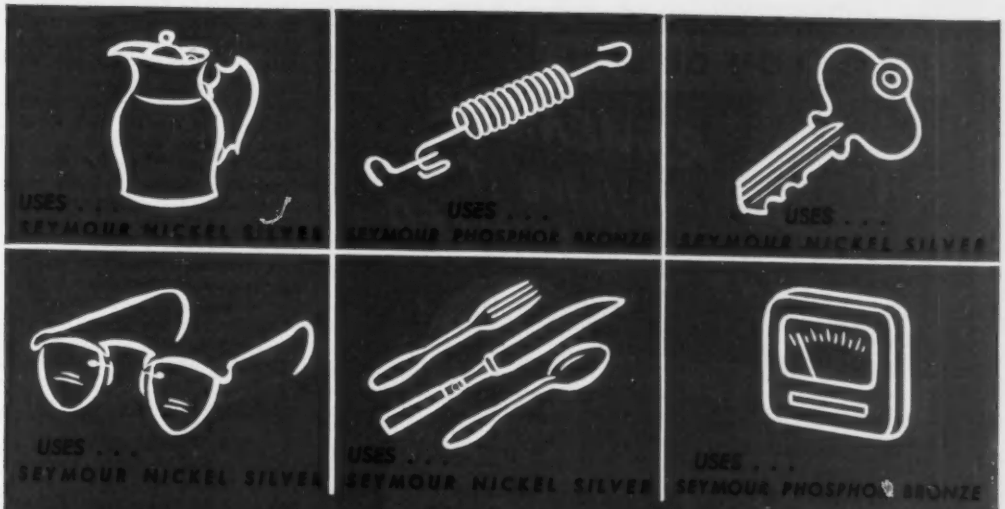
Aware of the controversial nature of the subject, the author has tried to give a fair appraisal of the most commonly used powders, mills, presses, and furnaces on the basis of personal experience and of catalogs and advertisements by the various producers.

The subject of pressing of powders is given considerable space and coverage of both the theoretical and the practical aspects is attempted. Pressing at elevated temperatures is intentionally treated before a discussion of sintering.

A.S.T.M. Standards On Light Metals and Alloys

Published by the American Society for Testing Materials, 1916 *Race St., Philadelphia* 3, *Pa.* 160 *pages*, 6x9 *in. Non-members,* $2.25 *per copy;* $1.75 *to A. S. T. M. members.*

This is a compilation of ASTM specifications and methods of test for light metals and alloys, prepared in convenient form. It includes not only those specifications and methods of



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A *heavy* coating of zinc applied to iron or steel by the Hot-Dip Galvanizing process provides the utmost protection against rust. Molten zinc forms a perfect bond with the metal, providing an effective seal against corrosive action of the elements. For an economical top-grade job of genuine Hot-Dip Galvanizing, send your materials to a member of the American Hot Dip Galvanizers Association. List of members available at Association's headquarters in the First National Bank Bldg., Pittsburgh 22, Pa.

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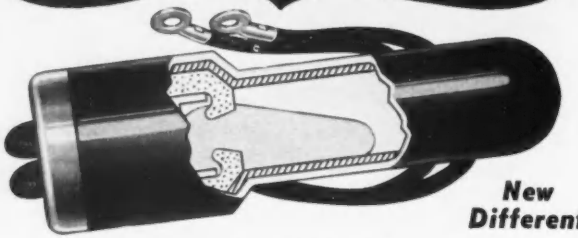

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Prices Reduced 28% to 55% on same capacity

★ Twice capacity of older models
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★ Lower operating angles

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test which come under the jurisdiction of Committee B-7 on Light Metals and Alloys, but also those for light metal alloy die castings, prepared by Committee B-6 on Die Castings, and those for aluminum wire and cable for electrical purposes, sponsored by Committee B-1 on Wires for Electrical Conductors. Several methods under the jurisdiction of Committee E-1 on Methods of Testing and Committee E-3 on Chemical Analysis of Metals have been added to make the compilation as useful as possible. In addition a specification for arc-welding electrodes under the jurisdiction of the AWS-ASTM Joint Committee on Filler Metal has been included.

Applied Mechanics

HARVEY F. GIRVIN, *professor of applied mechanics, Purdue University. Second Edition.* 417 *pages,* 6 x 9 *in. Published by International Textbook Co., Scranton 9, Pa.* $5.25.

The book deals exclusively with the study of the effect of forces on bodies at rest or in a state of uniform motion, the study of motion without reference to the forces that cause or influence the motion, and the study of the effect of unbalanced forces on the motion of bodies that therefore have accelerated or non-uniform motion.

Topics and their subdivisions are those usually covered in textbooks dealing with applied mechanics.

This second edition has been entirely reset. Illustrative examples have been added. Some sections have been considerably amplified, especially those dealing with kinematics and kinetics.

Problem material has been rearranged and many problems revised. The book now contains more than a thousand examples and problems. More than six hundred line drawings are included to visualize the concepts presented and give problem data.

Tables of Bessel Functions Of Fractional Order, Vol. II

Prepared by The Computation Laboratory of the National Applied Mathematics Laboratories, National Bureau of Standards. Published by Columbia University Press, Morningside Heights, New York. 8x11¾, 365 *pages.* $10.

The present volume, devoted to the tabulation of $I_\nu(x)$ for $\pm\nu = \frac{1}{4}, \frac{1}{3}, \frac{2}{3}, \frac{3}{4}$, is a sequel to the volume containing $J_\nu(x)$ for the same orders. The functional values in both volumes are given either to ten decimal places or to ten significant figures. The interval in the argument has been so chosen that interpolation with the aid of the tabulated second central differ-

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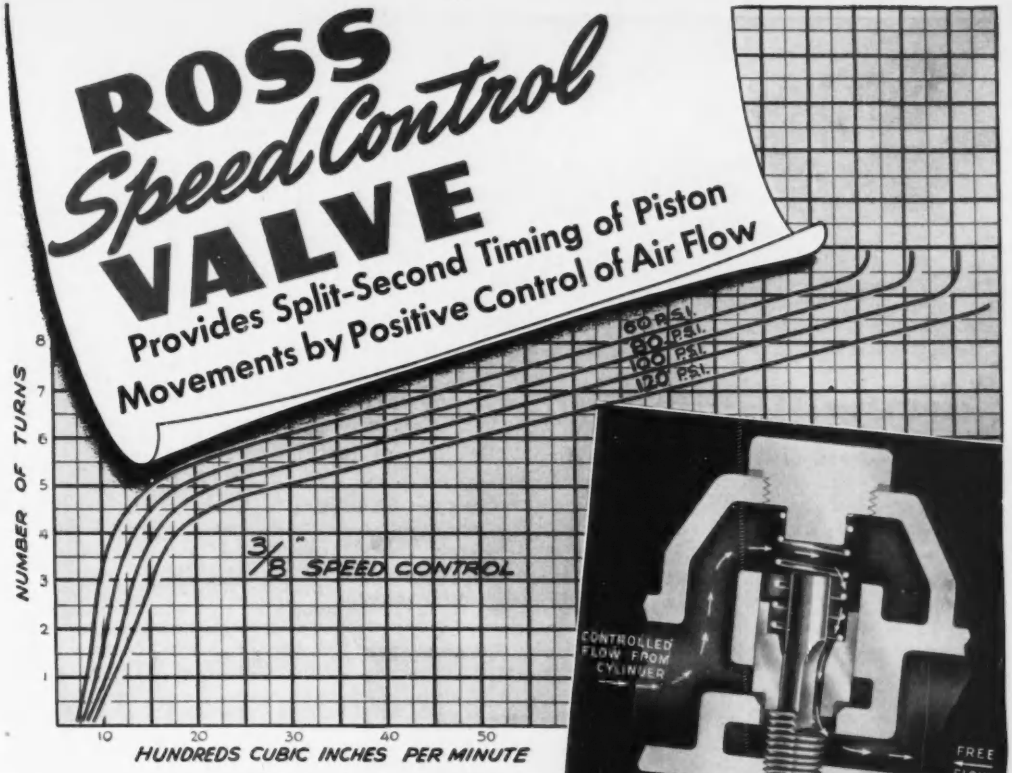

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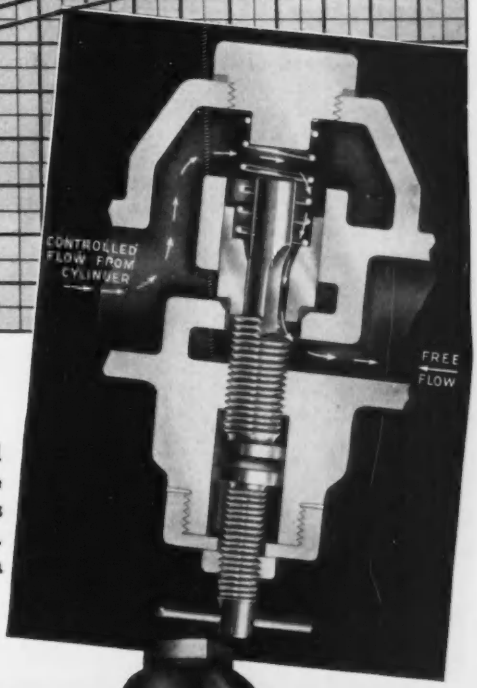

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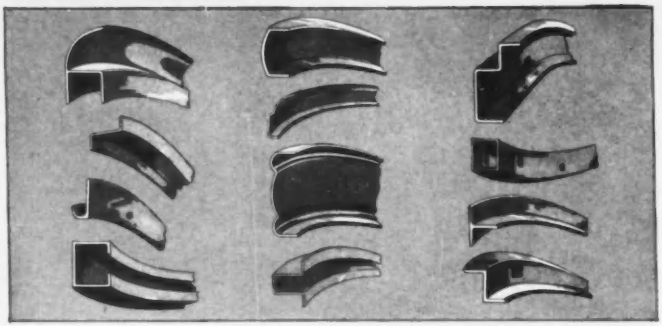

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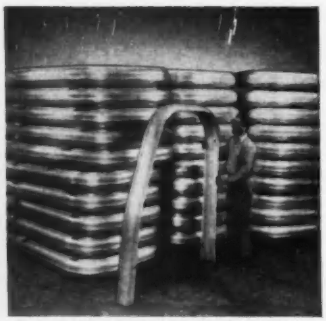

Outer profile structural member formed in one piece from aluminum alloy extrusion.

Trailer roof cap (left), formerly an assembled section, is formed in one piece by BATH. Coach frame (right) includes reverse bends.

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The tables of $I_\nu(x)$ in the present volume cover a range of x from 0 to 25. The function $e^{-x} I_\nu(x)$ is tabulated in the range of x between 25 and 30,000 at various intervals. With the aid of these values it is possible to compute $I_\nu(x)$ in this range of x. For x greater than 30,000 an accuracy of at least nine significant figures can be obtained with the first two terms of the aymtotic expressions for $I_\nu(x)$.

In addition, the present volume contains tables of the Everett interpolation coefficients, a list of constants, and a table for facilitating interpolation with respect to ν. Volume I gave a complete explanation of this table.

Engineering Materials and Processes

Metals and Plastics

WILLIAM HOWARD CLAPP, *Professor of Mechanism and Machine Design, Emeritus; and Donald Sherman Clark, Associate Professor Mechanical Engineering; both of California Institute of Technology. Second edition.* 526 *pages,* 6 × 9 *in. Published by International Textbook Co., Scranton* 9, *Pa.* $6.50.

The content of this second edition is essentially the same as that of the first edition, the wide adoption of which has substantiated the authors' belief in the necessity of presenting to engineers in training the basic information on the properties of materials and technological processes.

Chapters on cooling curves and equilibrium diagrams, plastics, castings, and methods of joining metals have undergone the greatest changes as presented in the second edition. The chapter on plastics has been completely rewritten.

The material has been gathered from many books, catalogs, magazines and professional papers. It presents a brief treatment of the physical properties and uses of the principal engineering materials. Methods for processing these materials are also described.

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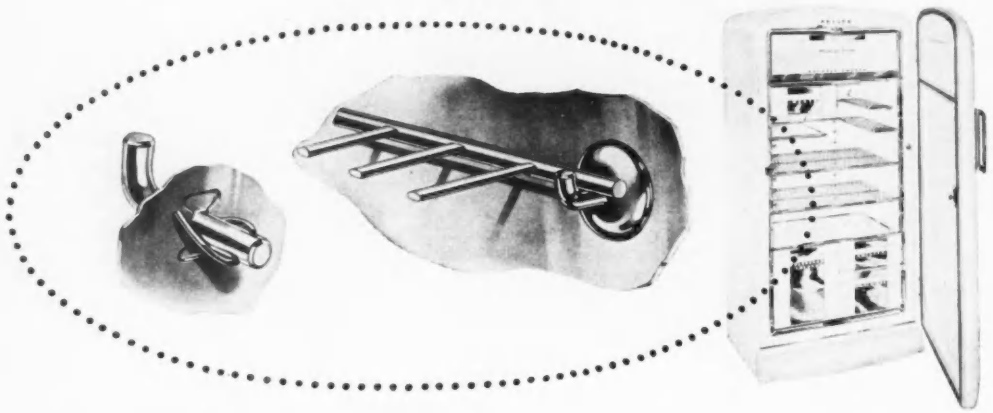
The secret behind Philco's "adjustable shelves"



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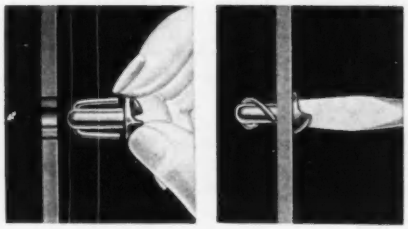
HERE'S HOW SPRING-LOCKS WORK



The U-shaped stainless steel wire on the shank starts with its legs straight on initial insertion. When the Spring-Lock is turned 180 degrees, the legs bend so that the leg ends bear against the back of the sheet, providing a sure-tight fit. Another 90 degree turn moves the leg ends until they register with the opening, and the Spring-Lock is free for removal.

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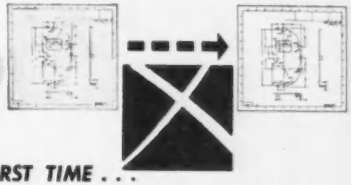

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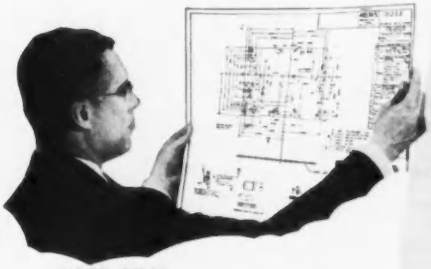

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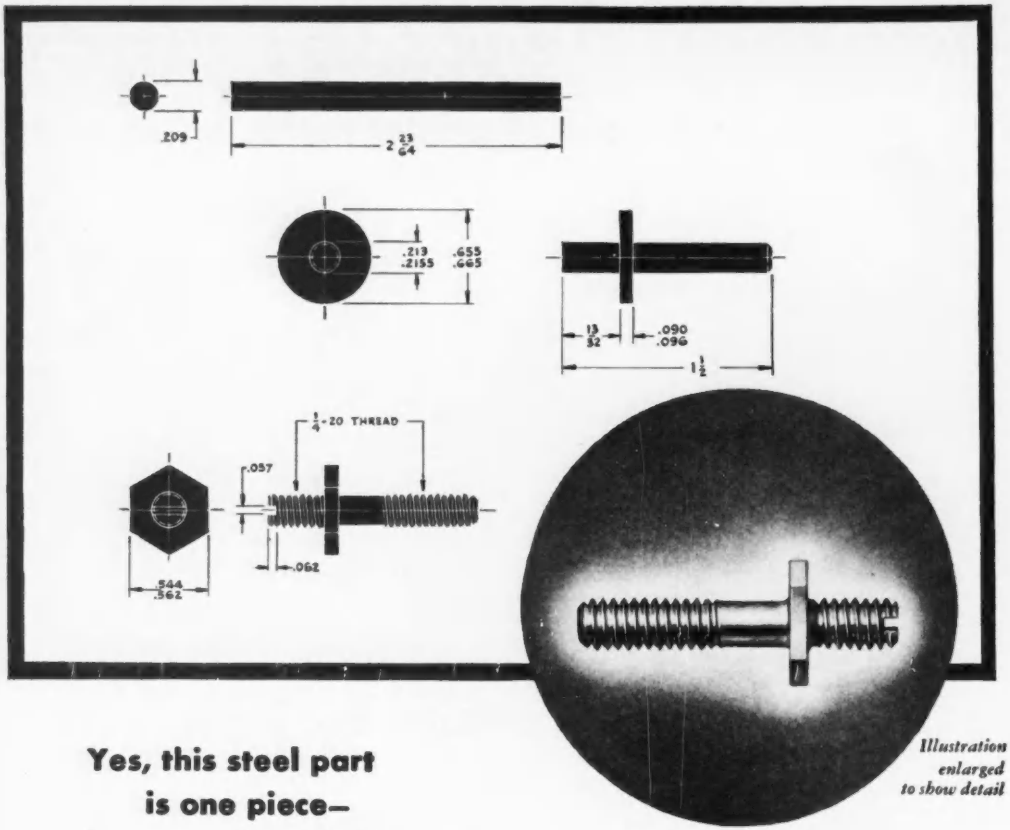

Illustration enlarged to show detail

Yes, this steel part is one piece— how was it made?

This is no puzzle to designers who know the possibilities of *cold heading*.

It *could* be milled from bar or cut out of a hex rod on a screw machine, but that would mean wasting about 75% of the metal.

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Consider parts you are using now—could they be made better and cheaper by cold heading? What about parts now on the drawing board? Unusual specifications can often best be met by cold heading.

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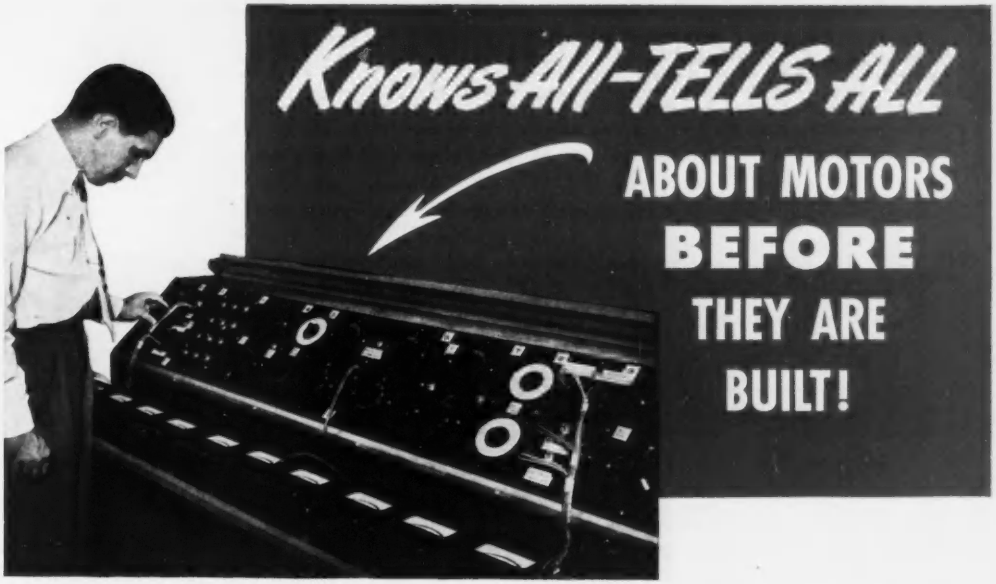

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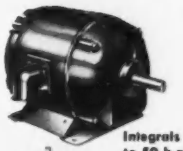

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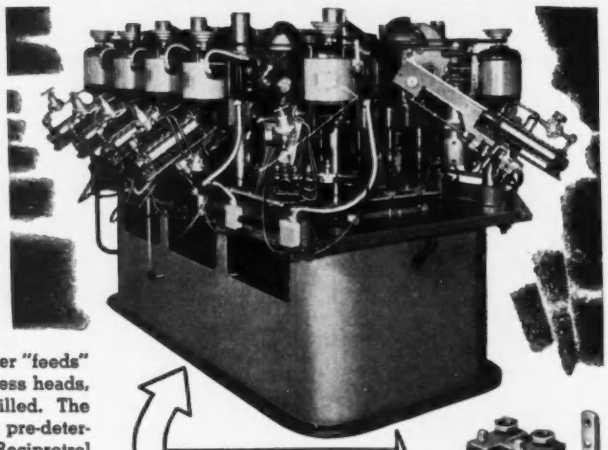

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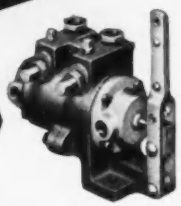

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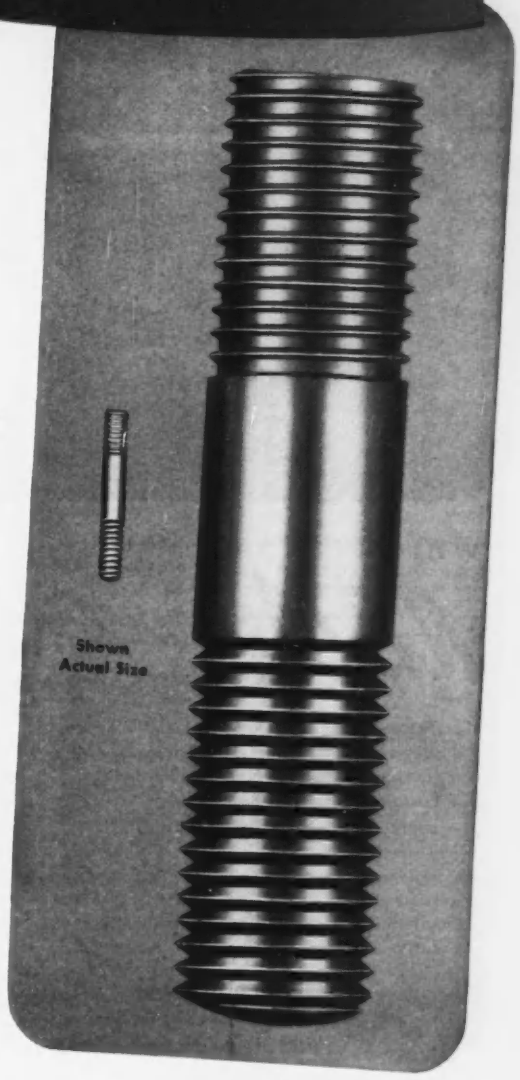
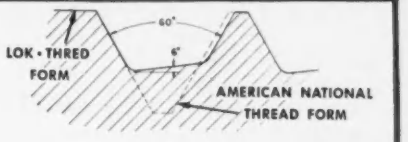


SEE THE DIFFERENCE!



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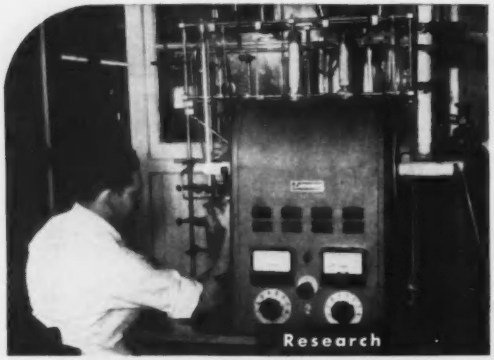

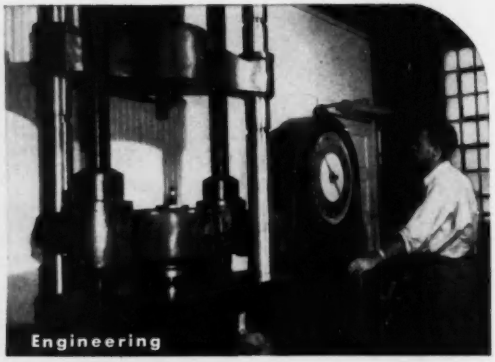

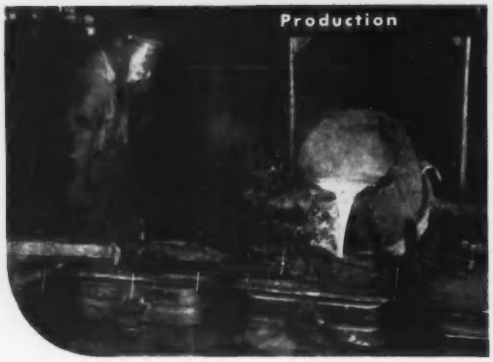

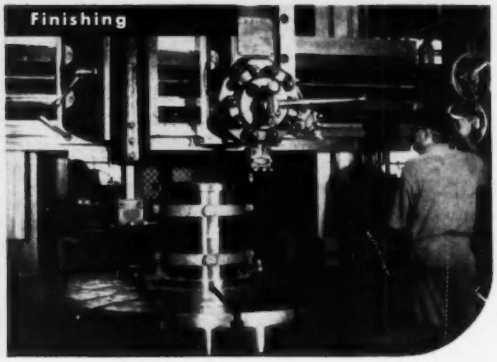

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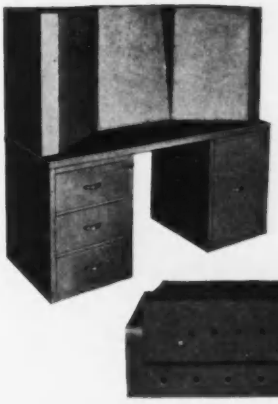
For Blue Ribbon Quality in Sheet Metal Housings

Send Your Blueprints to Karp

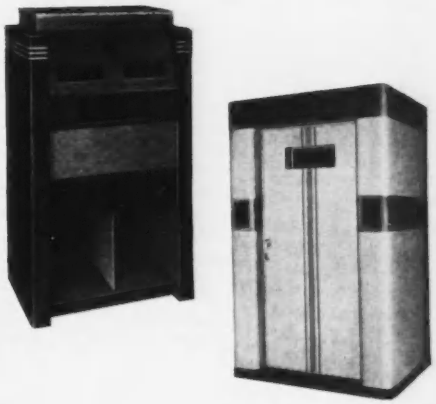
When manufacturers of electronic, radio and electrical apparatus, situated as far as 2000 miles and more from our plant, insist on Karp sheet metal craftsmanship, there must be good and profitable reasons.

One important reason is that Karp-constructed cabinets, enclosures, housings and chassis are custom-built to individual requirements; so precisely and uniformly made that time and money are saved on your assembly line. Another reason is that Karp builds good looks and streamlined styling into the product, giving you added sales and profit advantages.

Remember the Karp blueprint man symbolizes blue ribbon quality in cabinets, housings, enclosures and chassis. Tell us your needs. Get our quotations.



- *Any metal*
- *Any gauge*
- *Any size*
- *Any quantity*
- *Any finish*



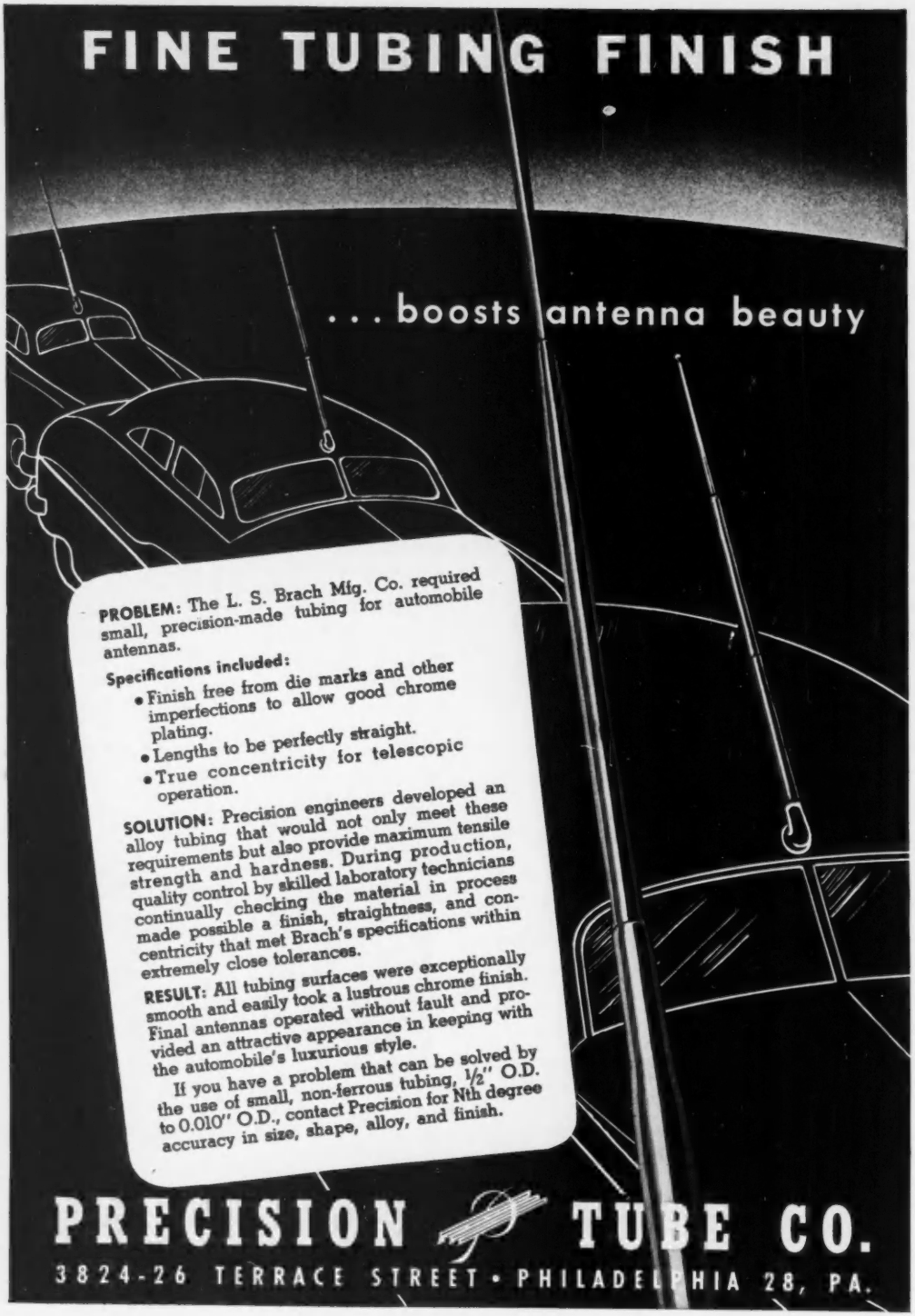
KARP METAL PRODUCTS CO., INC.

241 - 63rd STREET, BROOKLYN 20, N. Y.

Custom Craftsmen in Sheet Metal

FINE TUBING FINISH

. . . boosts antenna beauty



PROBLEM: The L. S. Brach Mfg. Co. required small, precision-made tubing for automobile antennas.

Specifications included:

- Finish free from die marks and other imperfections to allow good chrome plating.
- Lengths to be perfectly straight.
- True concentricity for telescopic operation.

SOLUTION: Precision engineers developed an alloy tubing that would not only meet these requirements but also provide maximum tensile strength and hardness. During production, quality control by skilled laboratory technicians continually checking the material in process made possible a finish, straightness, and concentricity that met Brach's specifications within extremely close tolerances.

RESULT: All tubing surfaces were exceptionally smooth and easily took a lustrous chrome finish. Final antennas operated without fault and provided an attractive appearance in keeping with the automobile's luxurious style.

If you have a problem that can be solved by the use of small, non-ferrous tubing, 1/2" O.D. to 0.010" O.D., contact Precision for Nth degree accuracy in size, shape, alloy, and finish.

PRECISION TUBE CO.

3824-26 TERRACE STREET • PHILADELPHIA 28, PA.

BACK IN THE 1880's

WHEN THE FIRST PNEUMATIC TIRE WAS INVENTED

Koven

WAS MAKING INDIVIDUALIZED EQUIPMENT PARTS

All steel wax recovery unit consisting of a jacketed tank with a spiral coil condenser and rectangular receiver.

All alum... tank cond... and receiv...

For sixty-eight years, KOVEN engineers and craftsmen have been developing increasingly economical and efficient methods for fabricating individualized equipment parts. To the many equipment manufacturers who find it costly and time-consuming to build all the parts of an entire unit in their own plant, KOVEN supplies such parts made to exact specifications — often more quickly and at a lower cost.

Our complete modern facilities include machine, welding, galvanizing and painting shops. X-ray inspection insures quality control. Today, call or write KOVEN. One of our representatives will be glad to discuss your production problems — without obligation.

Plants:
Jersey City, N. J.
Dover N. J.

L. O. KOVEN & BRO., INC.
154 Ogden Ave., Jersey City 7, N. J.

KOVEN FOR INDIVIDUALIZED EQUIPMENT PARTS SINCE 1881

Textile roll with body of Meehanite Metal and cover of bronze, both cast centrifugally by Shenango-Penn to assure exceptional strength and life. Shenango-Penn offers modern machining facilities for completely finished parts (as shown) or any stage of completion desired.

How this textile roll might smooth out a problem for YOU

IF SYMMETRICAL parts (such as sleeves, liners, rings, bushings, rolls and roll covers) figure in the machinery you build or operate, the above roll has qualities that could probably save you time and money.

The roll's body is Meehanite Metal—a big advantage in itself. The cover is bronze. Both are Shenango-Penn *centrifugal* castings. This means fine-grain, *pressure-dense* metal, assuring exceptional strength and hardness, and permitting the finest kind of finish. You just can't beat this combination for resistance to wear, breakage and distortion . . . for *long life!*

That's why Shenango-Penn is continually producing symmetrical, annular and tubular parts, large and small, for many services in many industries. Send for free bulletins on either ferrous or non-ferrous made-to-order centrifugal castings or on *centrifugally cast* bronze bushing stock in standard sizes.

SHENANGO-PENN

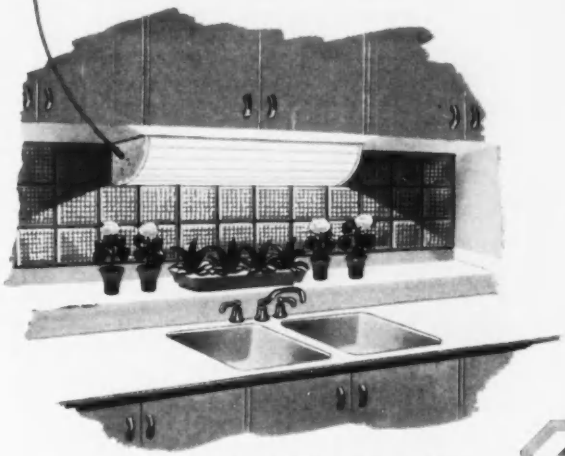
SHENANGO-PENN MOLD COMPANY
678 WEST THIRD STREET • DOVER, OHIO
Executive Offices: Pittsburgh, Pa.

ALL BRONZES • MONEL METAL
NI-RESIST • MEEHANITE METAL

Fluorescent lighting fixture for corner installation between ceiling and wall. Designed especially for Koppers "Moonglow" Polystyrene 8. Manufacturer: Winfield Electric Company, 164 N. Ada Street, Chicago 22, Ill. Extruder: The Anesite Company.

● Lighting fixture makers have long been looking for a way to obtain a soft white light . . . not too bright . . . not too dim . . . but easy on the eyes. Koppers has solved this problem by developing a new transluscent color called "Moonglow," made from Polystyrene 8.

Fixtures designed around the use of "Moonglow" are ideal for offices, industrial plants, bathrooms, kitchens and automobiles. They direct maximum light where you want it without glare.



chief advantages

OF "MOONGLOW" POLYSTYRENE 8

- You can get just the right degree of light transmission and diffusion combined with proper opacity or hiding power. This assures maximum light without showing the tube in fluorescent lights or the filament in incandescent lights.
- High heat distortion temperature, 200°F. assures dimensional stability.
- Light weight results in less weight suspended from ceiling and in lower shipping costs.
- Can be injection molded or extruded in any desired shape and easily cut to proper length. This reduces labor, time, and material costs.
- Flexibility permits shield to be snapped into position, saving assembly time and maintenance time after installation.
- The use of plastic in the shield permits a minimum of metal framing and therefore allows a maximum of light transmission area.

RE-DESIGN FOR LOWER COSTS

The Winfield Electric Company has already redesigned their fixtures to take advantage of the many cost-saving features of Koppers "Moonglow" Polystyrene 8. Why not discuss "Moonglow" with our engineers or write for complete information?

KOPPERS COMPANY, INC.
Chemical Division Pittsburgh 19, Pa.
Regional offices: New York Boston, Chicago and San Francisco

KOPPERS

Koppers *Perfected* Plastics

• POLYSTYRENE • ETHYL CELLULOSE • CELLULOSE ACETATE

Koppers Company, Inc.
Chemical Division, Dept. PE-11
Pittsburgh 19, Pa.

Please send me more information on Koppers "Moonglow" and a sample chip. I am a molder ☐ extruder ☐ other ☐.

Name ..... Title .....

Company .....

Address .....

City ..... State .....

USE THE NYLON

HEYCO

STRAIN RELIEF BUSHING

to anchor the cord set to your electrically operated

MACHINES, EQUIPMENT & APPLIANCES

TWO STANDARD HEYCO TYPES
. . . for all wire sizes

● The Nylon Heyco is an insulating grommet that is snapped into a hole in the chassis of a product. It anchors the cord set firmly to the chassis and imparts a positive non-slip grip—it does not injure the wire. Product life is greatly increased by preventing all strain on terminal connections as well as preventing cord wear at chassis entrance.

IT'S EASY TO APPLY HEYCO
1. Slip HEYCO on wire.
2. Snap HEYCO into hole.

Here's what Heyco does-

1. Absorbs cord pull, push and torque
2. Insulates wire from chassis
3. Prevents wire from fraying
4. Eliminates tying wire knots
5. Improves product appearance at low cost

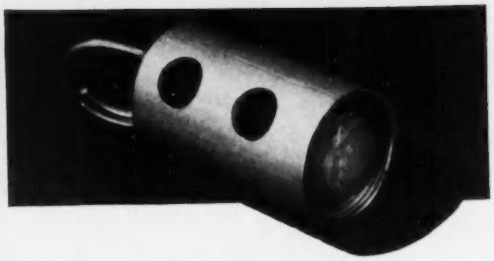
TEST SAMPLES WILL BE SENT ON RECEIPT OF WIRE SPECIFICATIONS

HEYMAN MANUFACTURING COMPANY
KENILWORTH 3, NEW JERSEY

In Canada approved by Canadian Standards Association No. 8919

HEYCO ELIMINATES STRAIN ON TERMINALS!

Where Can You Use the Unusual Properties of NYLON Rod?

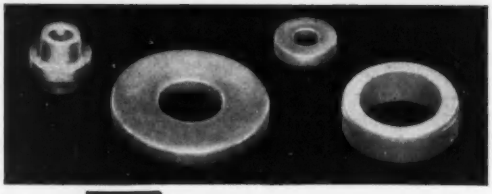


EXCELLENT WEAR RESISTANCE combined with unique seating characteristics makes this nylon rod an ideal material for machining into valve discs. Other resilient materials tried in this safety valve were found to creep under spring compression or stick to the valve seat. FM-3001 Nylon is flexible enough to conform exactly to the valve's seating surface, has a recovery characteristic which quickly seals the slightest leak, and has relatively low hygroscopic expansion.

Check This Combination of Physicals *Plus* LOW COST MACHINING

FM-10001 Nylon rod was selected for these precision spacers, washers and bushings because it has a somewhat higher softening point than other thermoplastics, and because nylon is fungus resistant.

The easy-machining characteristics of nylon rod gave economical production of these precision parts. Costly molds were not needed, and design changes can be made at minimum cost.



Useful Engineering Data covering Nylon Rod and Strip are contained in this folder. For your copy, just drop us a note on your company letterhead.

the POLYMER CORPORATION
of PENNSYLVANIA

201 GANSTER BUILDING, READING, PENNSYLVANIA

ASK STOKES

REEL SAVINGS from RE-DESIGN

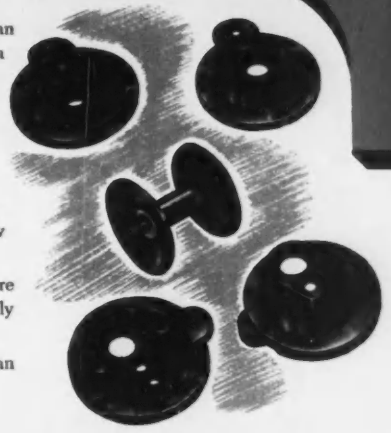
WHEN re-design of a molded plastics product can eliminate 90% of the former labor cost, that is a major accomplishment. . .

Horrocks-Ibbotson of Utica, New York, re-designed their famous Sea Level Winding Reel for molding on Stokes fully automatic presses.

Production rate of the side pieces was stepped up from the old rate of 60 per hour to 270 per hour; press labor cost was cut 90%; deburring costs now approach zero; material losses from 10% to 4%.

Stokes completely automatic molding machines are *cost-saving* units . . . designed to produce precisely accurate parts, economically and dependably.

Stokes can tell you whether your plastic parts can be profitably produced by automatic molding . . . just send the parts or blueprints for free analysis.



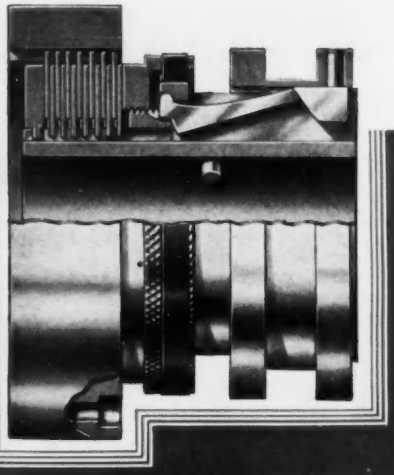
F. J. STOKES MACHINE COMPANY
5900 TABOR ROAD
PHILADELPHIA 20, PA.

FJS

WRITE for Bulletin No. 741 describing the Stokes Completely Automatic high-production Molding Press.

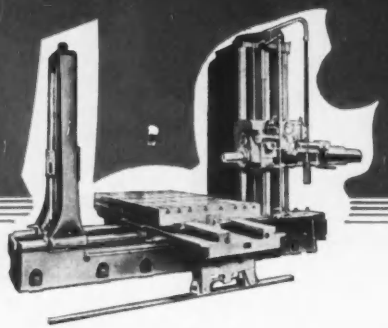
Stokes makes Vacuum and Special Processing Equipment, High Vacuum Pumps and Gages, Pharmaceutical Equipment, Industrial Tabletting and Powder Metal Presses, Plastics Molding Presses, Water Stills and Special Machinery.

STOKES KNOWS HOW



MAXITORQ

KEEPS GOOD COMPANY



We continue our "Good Company" series this month with the permission of Giddings & Lewis Machine Tool Company who have adopted the Maxitorq Floating Disc Clutch for their No. 351-T Table Type Horizontal Boring, Drilling and Milling Machine. A single, wet plate Maxitorq controls the power transmission in the feed and rapid traverse unit.

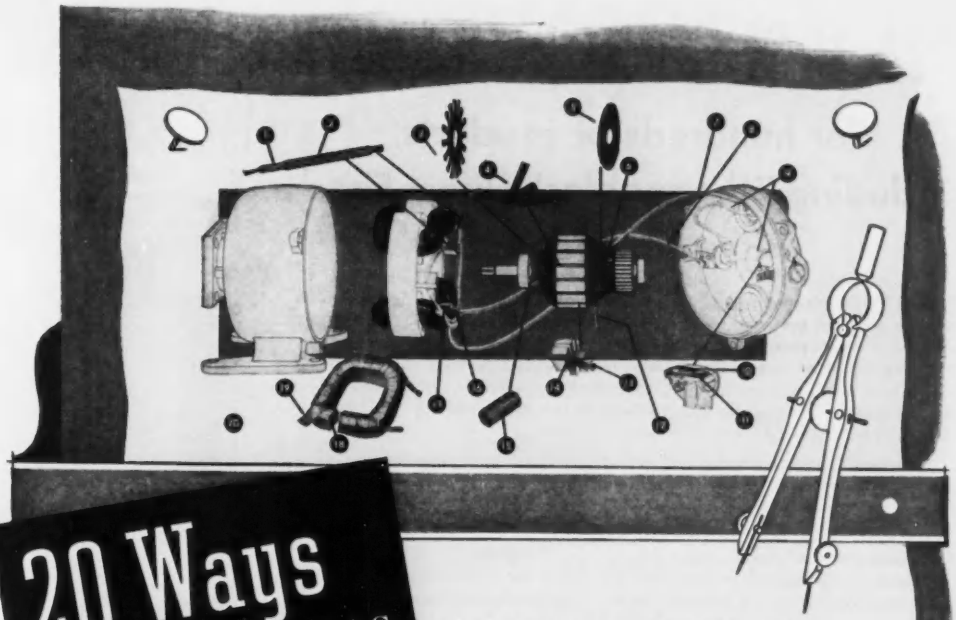
Maxitorq features that win approval from builders of machine tools, machinery and a wide variety of motorized products include: compact design; Separator Springs that keep discs apart to prevent drag, abrasion and heating in neutral; assembly, adjustment and take-apart without tools; and complete assembly shipments so that clutch is ready to slip onto a shaft.

Maxitorq engineers will give you specific and practical recommendations for smooth, dependable power transmission.

Send for Catalog PE11

SCJ48

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT



20 Ways TO USE FIBERGLAS GLASS-BASE ELECTRICAL INSULATING MATERIALS IN ELECTRIC MOTOR DESIGN

KEY

1. Field Coil Lead Wire Insulation (Made with Fiberglas yarns).
2. Sleeving or Tubing (Braided with Fiberglas yarns).
3. Armature End Cap (Laminate reinforced with Fiberglas fibers).
4. Armature Slot Wedges (Laminate reinforced with Fiberglas fibers).
5. Armature Coil Lead Separator (Cloth or tape woven of Fiberglas yarns).
6. Armature Coil Leads (Tied with Fiberglas cord).
7. Field Coil Live Terminal Lead Wire Insulation (Made with Fiberglas yarns).
8. Field Coil Ground Lead Wire Insulation (Made with Fiberglas yarns).
9. Armature Terminal Lead Wires Insulation (Made with Fiberglas yarns).
10. Brush Holder (Tube made of laminate reinforced with Fiberglas fibers).
11. Brush Cap (Molded part reinforced with Fiberglas fibers).
12. Armature Coil Lead Protection (Sleeving braided with Fiberglas yarns).
13. Armature Coil Magnet Wire Insulation (Made with Fiberglas yarns).
14. Armature Slot Liner (Cloth or cloth and mica combination sheet made with Fiberglas yarns).
15. Armature Shaft Insulation (Sleeving or tubing braided with Fiberglas yarns).
16. Field Coil Lead Support (Tape woven of Fiberglas yarns).
17. Field Coil Hold-Down Pin (Laminate reinforced with Fiberglas fibers).
18. Field Coil Magnet Wire Insulation (Made with Fiberglas yarns).
19. Field Coil Wrapping (Tape woven of Fiberglas yarns)
20. Commutator Lead Support Washers—Not Shown—(Laminate reinforced with Fiberglas fibers).

Fiberglas* glass-base electrical insulating materials are available to the design engineer in the form of yarns, braided sleeving and tubing, woven cloth and tape, cordage, sheets of cloth and mica combined, varnished cloth and varnished tape, and laminates reinforced with glass fibers.

The basic properties of the Fiberglas component in these materials are high heat resistance, high heat conductivity, high moisture resistance, high tensile strength, long life, and a space-saving factor that contributes to compact design.

These properties have led to the wide use of Fiberglas glass-base insulating materials in equipment designed to operate under Class B and Class H conditions.

Today, however, the use of these materials in equipment designed to operate under less severe Class A conditions is increasing... because designers and engineers of quality electrical equipment want the safety factor and customer-satisfaction insurance which the Fiberglas yarns help provide.

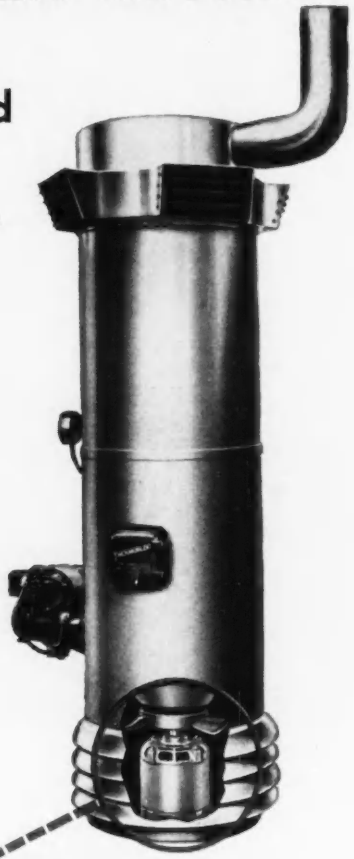
A new catalog of Fiberglas glass-base electrical insulating materials is available. Write for a copy. Owens-Corning Fiberglas Corporation, Textile Products Division, Dept. 807, 16 East 56th Street, New York 22, N. Y.

OWENS-CORNING FIBERGLAS

*Fiberglas is the trade-mark (Registered U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for a variety of products made of or with glass fibers.

A. O. Smith Builds ELECTRIC MOTORS

for hundreds of products, including "Thermobloc" Direct Fired Industrial Heaters



Typical of the many problems A.O. Smith has solved in engineering electric motors to specific product requirements is that encountered in providing blower power for the "Thermobloc," pictured here. Since the diameter of a standard-frame motor would restrict the required air flow of 4000 cu. ft. per minute, A.O. Smith engineered 1 full hp into a special small-diameter design, in a frame of less than standard size, which permits full flow of air into the heater.

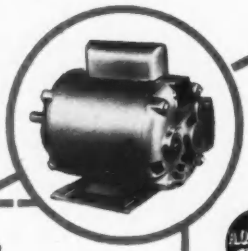
The research and engineering staff at A. O. Smith, where research itself has long been "big business," is at your service to help integrate motor design with your product design.

If you are seeking improved performance in your product, or if you require special characteristics in your power component—in either standard or custom-built electric motors—consult the A.O. Smith sales engineer. Or send the coupon below for additional information.

THERMOBLOC, product of Thermobloc Division, Prat-Daniel Corp., East Port Chester, Conn., is a compact, draft-free, direct-fired unit heater for high-efficiency space heating. This compact unit, 10 ft. x 30 in., operates with No. 3 fuel oil or gas at 80 to 85% efficiency, delivering 550,000 BTU per hour. Heat throw covers 5000 to 6500 sq. ft. floor space without ducts.

A. O. SMITH ELECTRIC MOTOR for the "Thermobloc," to drive the large blower fan, is 1 hp, 1800 rpm, single phase, mounted vertically in the base of the unit. Pre-lubricated, sealed-type ball bearings are self-protected from dirt and dust. Light and compact, this motor provides 1 hp in a smaller than standard frame.

Ask the A. O. Smith sales engineer about electric motors for both standard and special uses



24-HOUR MOTOR SERVICE

To more than 200 authorized service stations the A. O. Smith Product Service Division provides fast, low-cost electric-motor service, on a 24-hour, off-the-shelf basis. Factory Service Branches and Warehouses at Union, N.J., Chicago 17, Dallas 2, Los Angeles 12.

A.O. Smith Corporation, Dept. PE-1149
5701 Smithway St.,
Los Angeles 22, Calif.

Without obligation, send us full information on A.O. Smith Electric Motors.

Name_____

Firm_____

Street_____

City_____ State_____

75th ANNIVERSARY 1874 - 1949

A.O.Smith

ELECTRIC MOTORS

Boston • New York • Pittsburgh • Cincinnati • Syracuse
Cleveland • Atlanta • Chicago • Minneapolis • Detroit
Milwaukee • Houston • Tulsa • Dallas • Denver • Seattle
Los Angeles • San Francisco
Motor Export Department: 13 East 40th St., New York 16

They can't stand *Spots* before their *eyes!*

No, the people in our Quality Control Group can't stand even *one* spot before their eyes, when it comes to okaying a bearing, because they are passing on one of the most precise parts that goes into an engine assembly.

In the case of the plain copper-lead main bearing shown above, this okay must be given 87 times.

On more complex items—such as flanged bearings—an even greater number of tests is necessary.

These manufacturing controls pay off for you! They are your assurance of high quality and exact adherence to your specifications. You get maximum performance when you use Federal-Mogul *silent* sleeve bearings. Consult our engineers on your requirements.

HIGH SPEED, high temperature, automotive type bearings available in many combinations.

SPEED & LOAD bearings for pumps, compressors, industrial electric motors and similar uses.

HEAVY LOAD for big Diesels, power plants, etc.—bearings up to 27½" O.D., steel and bronze back.

BRONZE PARTS in many shapes, sizes; thrust washers, bushings; for many types of applications.

1899 • Fifty Years of Continuous Bearing Experience • 1949

FEDERAL-MOGUL

FEDERAL-MOGUL CORPORATION

FEDERAL Mogul *Silent* SLEEVE BEARINGS

11043 SHOEMAKER, DETROIT 13, MICH.

PROBLEM: Outboard bearings on extended pin roller chain conveyor . . . to withstand degreasing vapor, dipping bath fumes, high heat, water dip, steam, acid spray, etc.

SOLUTION: A Morganite bearing . . . the special bearing for special conditions . . . meets all requirements . . . is entirely self-lubricating under all conditions.

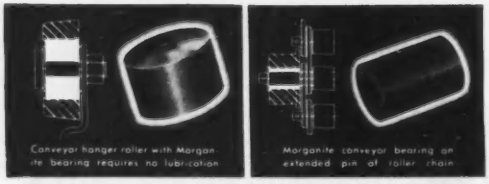
MORGANITE
SELF-LUBRICATING
CARBON BEARINGS

One application that clearly demonstrates the special properties of Morganite bearings is their use on conveyor belts involving continuous changes of atmosphere and temperature. Bearings, pump blades and seal rings of Morganite easily withstand these conditions . . . actually operate better when submerged in liquids. They are immune to oil, petroleum, water, brine, most acids and alkalies. Being self-lubricating they do not contaminate contacting liquids and materials with grease or oil, impart no odor or taste.

SEE OUR CATALOG IN SWEET'S FILE

Additional data on Morganite will be found in Sweet's File for Product Designers. For competent engineering help on specific problems consult a Morganite sales engineer. There is no obligation.

REGISTERED TRADE MARK **Morganite** INCORPORATED
LONG ISLAND CITY 1, NEW YORK


Conveyor hanger roller with Morganite bearing requires no lubrication
Morganite conveyor bearing on extended pin of roller chain

Manufacturers of Morganite Carbon Brushes for all motor and generator applications, and Morganite Carbon Piles.

2 Engines are Better than 1

This NEW Vegetable Harvester Is Powered by **2 WISCONSIN** Heavy-Duty *Air-Cooled* **ENGINES!**

Harvesting onions and other vegetables mechanically is a NEW idea for a NEW machine . . . The Dilts-Wetzel (Ithaca, Mich.) Vegetable Harvester, powered by TWO Wisconsin Heavy-Duty Air-Cooled Engines . . . one driving the unit . . . the other powering the harvesting mechanism.

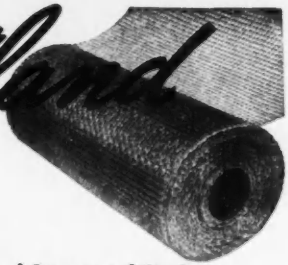
Peak efficiency and flexibility are always delivered, because the harvesting engine operates at uniform speed, regardless of the forward travel speed, and it shuts down entirely when moving to new locations. Furthermore, TWO Wisconsin Engines weigh less, cost less, use less fuel, and have lower part replacement costs than one large engine of comparable total horsepower.

Perhaps this offers an idea that can be advantageously applied to your equipment — for greater power, flexibility, efficiency, and economy. Your investigation is invited.

2 to 30 hp., single-cylinder, two-cylinder, and V-type four-cylinder models.

WISCONSIN MOTOR CORPORATION
World's Largest Builders of Heavy-Duty Air-Cooled Engines
MILWAUKEE 14, WISCONSIN, U. S. A.
Cable Address: WISMOTORCO

Cortland
BRAND
INDUSTRIAL WIRE CLOTH



For Mechanical and Structural Design

Whatever your design problem with wire cloth for mechanical or structural parts, call on Wickwire Brothers, Inc. — specialists in wire manufacturing since 1873 — for experienced information. Wickwire's CORTLAND Brand Industrial Wire Cloth is made to meet your specifications —

Sizes: One inch to 30 Mesh
Weaves: Square and special
Metals: Steel, Copper, Brass, Bronze, Aluminum, Stainless Steel, etc.
Gauge: 14 to 39 and special
Finish: Tinned, galvanized, painted or plain steel.
Widths: 24"-48" standard; also narrower or wider, and slit or cut to size.

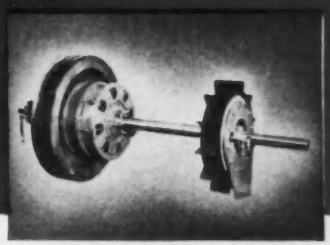
Inquiries about special grades and special applications are welcomed. Cortland Brand Industrial Wire Cloth can help you build your product better.

WB Cortland BRAND
WICKWIRE BROTHERS, INC., Cortland, N. Y.

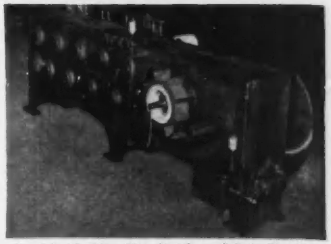
ONLY ONE MOVING PART

in this Fawick Clutch

Fawick Airflex Clutch or Brake Type CB



Fawick Airflex Clutch and Fawick Air-Ring Brake used for Package Unit Conversion for Cleveland 65D-84 Press.



Fawick Air-Ring Slip Clutch and Strip Tension Machine at Thomas Steel Co., Warren, Ohio, made by C. L. Gougler Machine Co., Kent, O.

Fawick Gap-Mounted Clutch Assembly on Pusey & Jones Corp. dryer drive at Marcalus Mfg. Co., East Paterson, New Jersey.

The rubber-and-fabric pneumatic tube faced with friction shoe assemblies is the only moving part in this Fawick Clutch. This part naturally stays in perfect adjustment at all times—automatically compensating for wear of the friction shoes.

Job-tested, Fawick Clutches meet the toughest operating conditions in many fields—petroleum, earth-moving, metalworking, rubber, paper, pulp and others.

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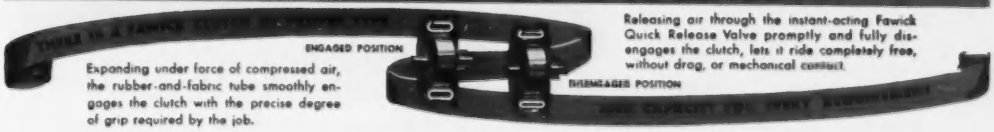

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Expanding under force of compressed air, the rubber-and-fabric tube smoothly engages the clutch with the precise degree of grip required by the job.

Releasing air through the instant-acting Fawick Quick Release Valve promptly and fully disengages the clutch, lets it ride completely free, without drag, or mechanical contact.

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All moving parts are controlled hydraulically by T-J Cylinders —on this Malleable Nut Production Machine designed and built by Roy Hays & Associates, Rockford, Ill., for the Wagner Malleable Products Co., Decatur, Ill.

It's *fully automatic*—the operator only places nuts in stations. Nine T-J Cylinders, 40 ton to ½ ton, help complete the job of cutting off sprue, sizing, boring, facing, chamfering and threading 2,500-¾ std. pipe thread nuts per hour.

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100 LB. or 50,000 LB.

32 YEARS EXPERIENCE

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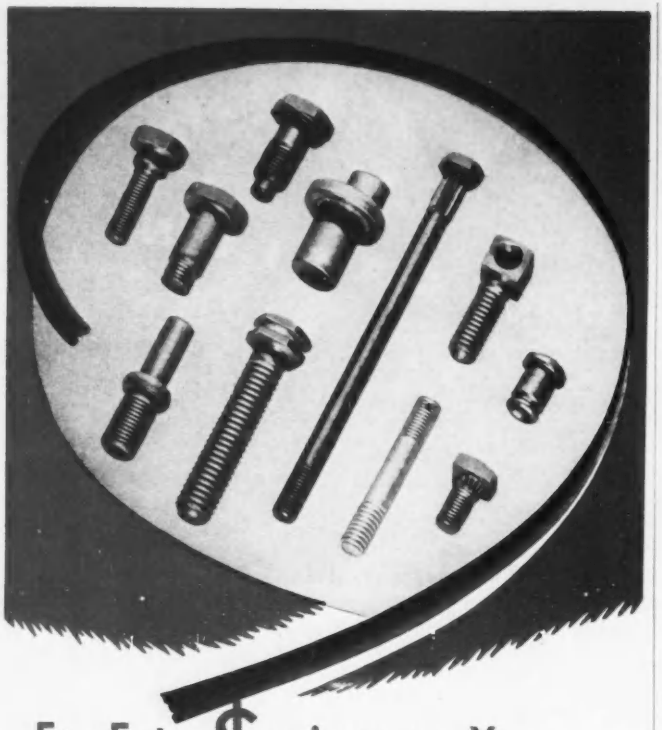

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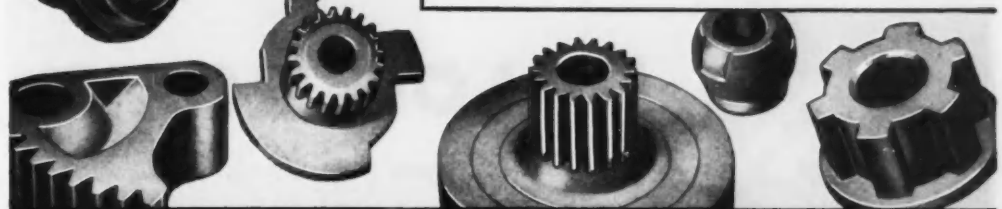

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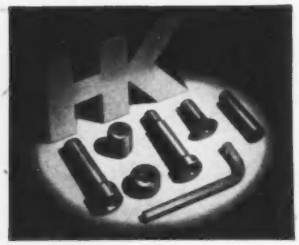

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NEW CATALOGS AND BULLETINS

A Reader Service To Help Keep Your Library Up-to-Date

(1) TUNING FORK RESONATORS — Philamon Laboratories 5717 Third Ave., Brooklyn 20, N. Y. Manual, 8 pp. This is a preliminary guide to the commercial and military applications of tuning fork resonators. A general description of the resonators and specifications of several models are given. Pictures and drawings are included.

(2) FABRICATING STEEL TUBING— The Ohio Seamless Tube Co., Shelby, Ohio. Handbook F-3, 48 pp. Explains the upsetting, spinning, fluting and swaging of steel tubing. Design considerations for fabricating or forging of tubing are stressed. There is also a small section on ordering and specifying tubing.

(3) SPROCKETS AND CHAINS — Cullman Wheel Co., 1344 Altgeld St., Chicago 14, Ill. Bulletin, 6 pp. Gives a new stock price list and specification listing of over 400 hub sprockets and single roller chains. Sprockets range from ⅜ to 1½ in. in pitch and from 3/16 to 1 in. in width.

(4) TEMPERATURE CONTROLS — H-B Instrument Co., 2633 Trenton Ave., Phila., Pa. Bulletin, 16 pp. A guide to the selection of both plant and laboratory equipment for signaling or controlling temperature. Includes thermo-regulators, thermostats, temperature controls, relays and select or switches. Also includes a simplified price list.

(5) SAFETY SWITCH — The Trumbull Electric Mfg. Co., Plainville, Conn. Bulletin, 6 pp. Exploded view photos and schematic drawings show construction details of HCI, high capacity interrupter safety switch. It is available in 30, 60, and 100 amp sizes, 2, 3, and 4 pole, fusible and no fuse models.

(6) STRAIN GAGES—The Baldwin Locomotive Works, Testing Equipment Dept., Phila. 42, Pa. Bulletin, 12 pp. A new price list of SR-4 strain gages. Includes drawings showing types and applications of several gages and specifications of gages listed with the price.

(7) HEAT CONTROLS — Westinghouse Electric Corp., Meadville, Pa. Brochure, 16 pp. Called "Therm-A-Neering". This booklet discusses heating units and heat controls for many applications. Several thermostats are shown with various applications of each. Specifications and general characteristics of each are given.

(8) HYDRAULIC OILS—E. F. Houghton & Co., Phil. 33, Pa. Booklet, 54 pp. This is a research manual on the specifications, properties, use of additives, qualities, and usage of various grades of hydraulic oils. It is illustrated and has many charts, diagrams, and tables to give a good coverage of oils used in many applications.

(9) CORROSION RESISTANT SHEET AND PLATE—The Duriron Co., Inc., Dayton 1, Ohio. Bulletin, 8 pp. Describes Durimet 20 sheet and plate corrosion resistant steel and gives a list of the common corrosives to which it is resistant. Also gives physical and chemical properties and mechanical strengths. Application pictures show the metal in use.

(10) ABRASIVE RESISTANT METAL— American Brake Shoe Co., 230 Park Ave., N. Y. 17, N. Y. Folder, 6 pp. Describes the physical properties of Thermalloy HC-250. A table compares properties of this metal with properties of three comparable materials. The metal is machinable in annealed condition, and can be rehardened to 650-750 Brinell.

(11) HEAVY-DUTY TRANSMISSIONS— Fuller Mfg. Co., Transmission Div., Kalamazoo 13F, Mich. Bulletin, 12 pp. Cutaway photos show construction of 16 models of heavy-duty transmissions. Gear ratios and clutch, brake, and clutch housing specifications of each model are given. Transmissions are for use with straight or tractor-type trucks engaged in heavy work.

(12) ROTARY BLOWERS — Roots-Connersville Blower Corp., 900 W. Mount St., Connersville, Ind. Bulletin, 8 pp. Covers the smaller size type AF rotary positive blowers, for pressure or suction service. They are available in 18 standard sizes with capacities ranging from 5 to 700, 5 to 415, and 15 to 245 cfm, with pressures ranging from 3 to 7 psi. Pictures and specifications are shown.

(13) MEEHANITE METAL CASTINGS— Meehanite Metal Corp., Pershing Square Bldg., New Rochelle, N. Y. Bulletin 32, 4 pp. A complete tabular summary of the engineering properties of the various types of Meehanite Castings available to industry. Gives property changes as affected by variations in section sizes.

(14) MERCURY SWITCHES—Minneapolis-Honeywell Regulator Co., Brown Instrument Div., Wayne and Roberts Aves., Phila. 44, Pa. Catalog 1343, 16 pp. Two basic types of switches are described and illustrated—The mercury-to-electrode and mercury-to-mercury. Applications, specifications, and engineering data given.

(15) SHADED PALE MOTORS—Russell Electric Co., 4501 S. Western Blvd., Chicago 9, Ill. Bulletins 2,000 and 1,000, 2 pp. Gives dimensions, ratings, and construction features of new type 350 two pole skeleton frame shaded pole induction motor. Motors run at 3,000 rpm., and have 1/10 to 1/15 hp ratings. Bulletin 1,000 describes type 230, which is similar but smaller than the type 350.

(16) DIE-LESS DUPLICATING—O'Neil-Irwin Mfg. Co., Lake City, Minn. Booklet, 40 pp. Shows methods of designing parts to be made without dies by use of Di-Acro system of die-less duplicating. Precision benders, shears, notchers, punches, brakes, and other such machines for metal forming are demonstrated.

(17) WIRE ROPE SOCKETS—Wire Rope Institute, Shoreham Bldg., Washington 5, D. C. Bulletin 1, 4 pp. Gives the industry standards for wire rope sockets. Drawings and complete sizes describe sockets.

(18) ANALYSIS OF PLATING SOLUTIONS — Hanson-Van Winkle-Munning Co., Matawan, N. J. Handbook, 28 pp. Tells how to use sampling apparatus, and give analytical methods for analyzing 13 types of plating solutions. Also includes many chemical tables.

(19) FLOW INSTRUMENTS AND CONTROL VALVES—Fisher and Porter Co., Hatboro, Pa. Bulletin 5,001, 24 pp. Pictures and descriptions of variable-area primary flow meters, frictionless, series-

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resonant circuit electrical transmitters, flowrate recorders, and many other such instruments. Also presents air-operated control mechanisms and diaphragm motor valves.

(30) SCREEN CLOTH — Hewitt-Robins, Inc., Robins Conveyors Div., 270 Passaic Ave., Passaic, N. J. Bulletin 112-A, 16 pp. Tables and specifications aid in selection of wire screen for specific types of service. Wire screen is used in processing sand, stone, coal, coke, and other such materials. The use of enamel-coated wire is stressed for longer screen life.

(31) V-BELT DRIVE COMPONENTS—Browning Mfg. Co., Inc., Maysville, Ky. Catalog V-136-E, 74 pp. Has complete tabulated engineering specifications and sizes for sheaves, bushings, keystock, belts, and other V-belt drive parts. This booklet contains an unusual amount of factual information.

(32) STEEL WELDING RINGS — Tube Turns, Inc., Louisville 1, Ky. Bulletin 5.02, 20 pp. Explains use of welding rings. These rings are inserted into the ends of pipe, fittings, or valves to back up roots of single-welded butt joints. The bulletin covers code rules for use, ring types, recommended practices, macrographs of welds, and a section on ring design.

(33) TUBE FITTINGS—The Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio. Catalog 203, 56 pp. Drawings show basic design of each type of fitting, and complete specifications are given in tables. In addition to the many fittings listed, there are tube benders and other types of tube fabricating equipment.

(34) LOCKNUTS — Security Lock Nut Corp., 1815 N. Long Ave., Chicago 39, Ill. Bulletin, 12 pp. Originally published by the American Institute of Bolt, Nut and Rivet Mfgrs., this bulletin is a round up of the main types of locknuts produced in this country. Gives a description, picture, principle of operation, and manufacturer of each.

(35) ENGINE GENERATOR SETS—International Diesel Electric Co., 13-02 Forty-fourth Ave., Long Island City 1, N. Y. Bulletin 112, 4 pp. Describes line of diesel and gasoline engine driven generator units with capacities ranging from 5 to 250 kw. Pictures, descriptions, and applications given.

(36) BALL AND ROLLER BEARINGS—Link Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. Catalog, 112 pp. Pictures, drawings, and section views show complete line of anti-friction components. Hanger blocks, bearings, pillow blocks, locknuts, washers and take-up blocks are only a few of the units listed. Complete tables of specifications and other engineering data given. There is also a section on bearing selection.

(37) HARDFACING RODS AND ELECTRODES—American Brake Shoe Co., 230 Park Avenue, New York 17, N. Y. Bulletin CC-3, 4 pp. A chart lists line of welding rods and electrodes and indicates type of service for each. Metallurgical and physical descriptions of each rod are arranged to simplify selection.

(38) AIR CLEANERS — Donaldson Co., Inc., 666 Pelham Blvd., St. Paul 4, Minn. Catalog, 40 pp. pictures, descriptions, and specifications given for line of air filters and gasoline tanks. Filters are for trucks, tractors, and other heavy equipment. Application pictures are also shown.

(39) APPLIANCE SWITCHES — Cutler-Hammer, Inc., Milwaukee 1, Wis. Catalog, 14 pp. Shows a line of toggle, rotary, pushbutton, door operated, and automotive switches and related equipment. These switches are available in a variety of mountings. Specifications and a price list are included.

(40) MULTIPLE V-BELT DRIVE—Fort Worth Steel and Machinery Co., 3600 McCart St., Fort Worth, Texas. Catalog section 50, 92 pp. Complete specifications and engineering information on all components of V-belt drives. Also, complete sections on formulas, hp ratings, drive selection, drive construction, take up allowances, distance calculations, and other related subjects.

(41) HOT-DIP ZINC-COATED STEEL—Sharon Steel Corp., Sharon, Pa. Bulletin, 12 pp. Explains uses, manufacture, and advantages of Galvanite, a special coated steel which is weather resisting, and paint holding.

(42) PRESSURE GAGES — American Chain and Cable Co., Inc., Helicoid Gage Div., Bridgeport 2, Conn. Bulletin, 16 pp. Explains principle of operation of the helicoid pressure gage. Helicoid movement replaces the usual spur gear movement to give linger life, less inertia in movement. Also shows pressure gage accessories. Prices are given.

(43) STOCK FORGINGS—Merrill Brothers, 56-02 Arnold Ave., Maspeth P. O. New York, N. Y. Catalog 51, 22 pp. Shows a line of forged handling devices kept in stock by the company. Includes turnbuckles, clevis nuts, shackles, eye bolts, sleeve nuts, coupling nuts, ring bolts and lifting clamps. Gives sizes, specifications, and prices.

(44) MANUAL CONTROL SWITCH—Micro Switch, Freeport, Ill. Data sheet 54, 55; 4 pp. Describes BZE-2RN4 switch with large button type actuator for manual control, and the OP-AR50 splash-proof switch with large plate actuator. Both are rated at 15 amps, 125, 250, or 460 v, alternating current.

(45) VIBRATION CONTROL—The Korfund Co., Inc., 48-15 32nd Place, Long Island City 1, N. Y. Bulletin LK 551, 4 pp. Explains operation of vibration isolators for machinery mountings. Units use coil springs and resilient inserts for damping action. Tabulated data gives dimensions, loads and weights, and other engineering information.

(46) SEALED RELAYS — Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif. Bulletin, 4 pp. Presents a new relay for a-c loads of 50 to 75 amps at 115 V, 400 cycles, or 25 amp at 270 V, 400 cycles. Relay is hermetically sealed. Gives complete engineering data.

(47) SELENIUM RECTIFIERS — Westinghouse Electric Corp., P. O. Box 868 Pittsburgh 30, Pa. Bulletin DB-19-025, 8 pp. Shows standard and high-voltage selenium rectifiers for power supplies and electronic circuits. Gives efficiency curves for both types. Also tabulates cell ratings, and shows schematic diagrams and formulas for calculating rectifier performance.

(48) AIR CONTROL VALVES—Ross Operating Valve Co., 120 E. Goldengate Ave., Detroit 3, Mich. Bulletin 202, 8 pp. Pictures, descriptions, and specifications are given for master and pilot valves for the control of single and double acting air cylinders. Typical valve installations also given.

(49) CORROSION RESISTANT PIPING —Taylor Forge and Pipe Works, Inc., P. O. Box 485, Chicago 90, Ill. Bulletin 485, 24 pp. A comprehensive treatment on stainless steel and nickel alloy anti-corrosion and anti-contamination piping. Economics, standards, advantages of welding, design information, and dimensional information are given.

(50) SEAL AND SHIELD BEARINGS—Waldes Kohinoor, Inc., Long Island City 1, N. Y. Charts, 5 pp. Gives specifications for use of Waldes Truarc Inverted Retaining Rings with seal and shield bearings.

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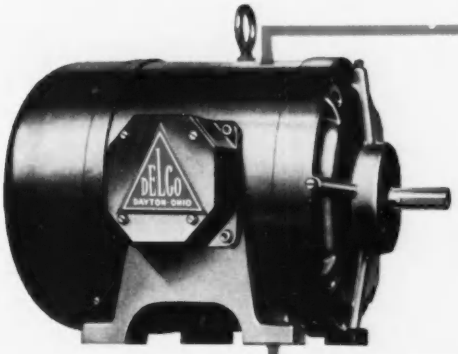

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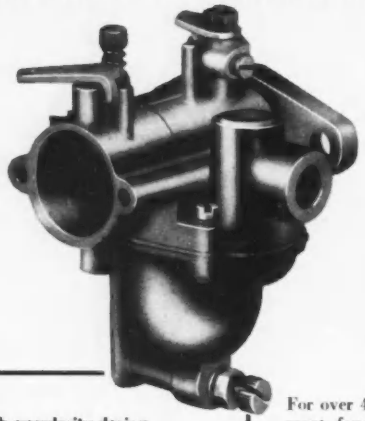

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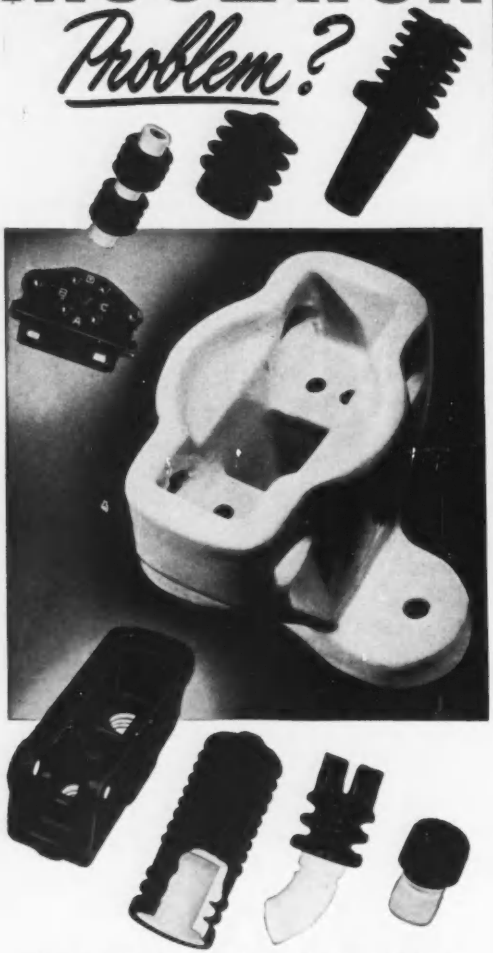

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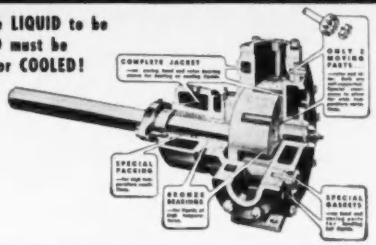

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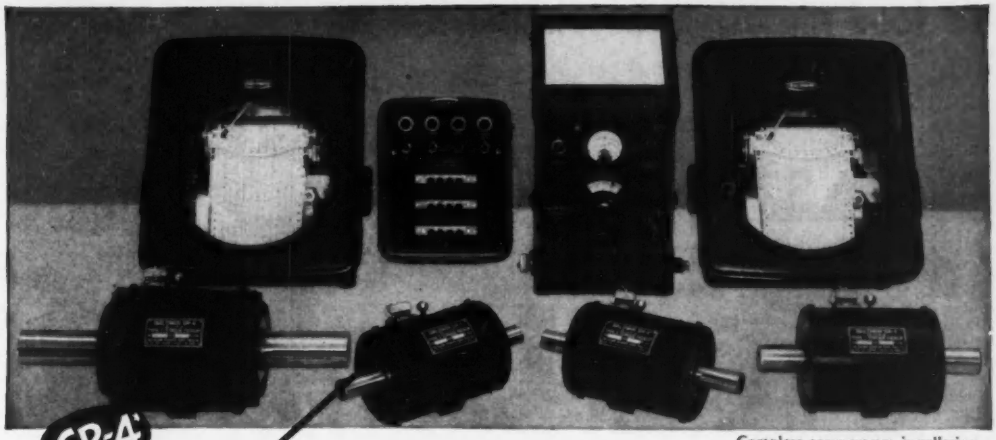

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Industry and Research have already utilized SR-4 torquemeters in a number of applications.

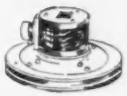
HELICOPTER ROTORS AND SHAFTS. Special torquemeter pickups have been developed for determining torque in tail rotor shafts and main rotor shafts during flight, as well as for checks on a test stand.

AUTOMOBILE STEERING WHEELS. Steering torque is easily and accurately determined by this unit. A small indicating meter is installed on the instrument panel of the test car.

SCREW DRIVING AND TAPPING. Important production information has been obtained with this torquemeter application, which permits determination of screw driving and tapping torques.

FUEL INJECTION SYSTEMS. Designed to measure vibratory torques in a fuel injection system, this torquemeter pickup has a separately mounted brush assembly.

CENTRIFUGAL PUMPS. The two torque shafts with a single separately-mounted brush assembly, and utilizing a single type T-1 instrument, cover two ranges—350 and 500 foot-pounds—in determining torque in centrifugal pumps.



HAND WHEEL—GUN RAISING. Developed to measure hand-wheel effort in a gun-raising mechanism, this torquemeter is driven by V-belt in rib. Torque is measured on the spokes.

Baldwin Torquemeters have been built for shafts from ¼ to 18 inches diameter, in capacities from 1 in. lbs. up to 750,000 in. lbs., and for speeds from zero to 10,000 rpm and above. General principles of construction and operation are covered in Bulletin 275, sent on request. A Baldwin representative will gladly discuss your torque-measuring problems with you, and suggest the proper unit to meet your needs.

The Baldwin Locomotive Works, Philadelphia 42, Pa., U. S. A. Offices: Boston, Chicago, Cleveland, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, St. Louis, Washington. In Canada: Peacock Bros., Ltd., Montreal, Quebec.

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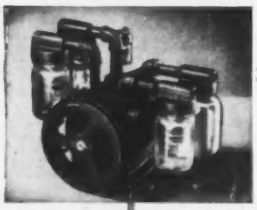
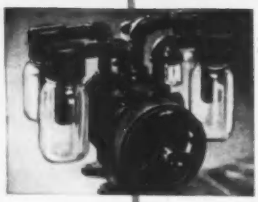
GAST ROTARY DESIGN GIVES *BOTH* VACUUM AND PRESSURE FOR FEEDING APPLICATIONS

Model 3040, new SINGLE CHAMBER PUMP—19 to 24 c.f.m. Pressure up to 10 p.s.i.—vacuum 15" and over.



Model 10 x 1040, small DUAL CHAMBER PUMP—9 c.f.m. from each chamber. Vacuum to 20", pressure to 15 p.s.i.



Model 11 x 1740, large DUAL CHAMBER PUMP—14 c.f.m. (to 10 p.s.i.) from pressure chamber; 9 c.f.m. (to 15") from vacuum chamber.

Look what these 3 new Air Pumps offer: They're designed to meet the specific needs of automatic feeding operations . . . handling paper, cardboard, thin metal, acetate, etc. They give *both* strong "blow" for separating—and large capacity low vacuum for "pick-up" of sheet materials.

With all the inherent advantages of Gast Rotary Design, they run quietly, producing large volume per horsepower at comparatively low speeds. They're trim in appearance and unusually compact. V-belt drives simplify installation and make speed control easy.

If you're building machines that can be fed with suction fingers—you'll want full details. Remember —"Air may be *your* Answer!"

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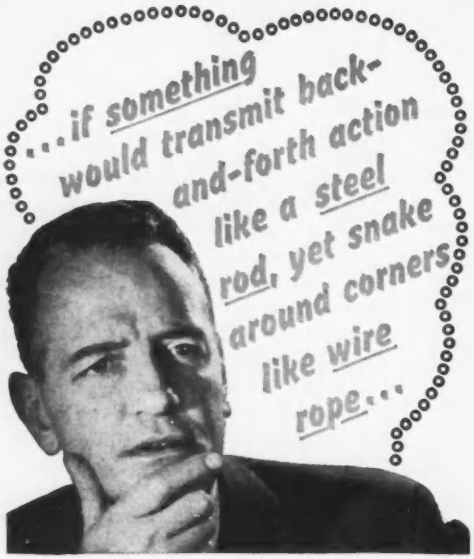

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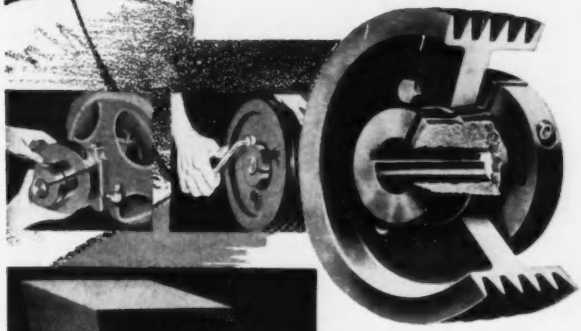

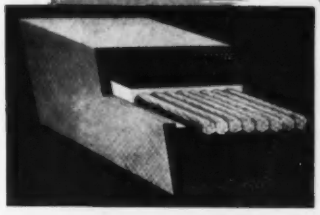

Worthington QD Sheave—Original Tapered Cone-Grip Sheave. Easy to Get On—Easy to Get Off—Yet Always Tight on the Shaft. The Quality-Built Sheave That Makes Alignment Easy—for Longer Belt Life.

The original tapered cone-grip of the two-piece QD Sheave produces a tighter fit on the shaft *than any other sheave.*

The tapered-bore rim, pulled up on the tapered-cone hub, causes a cone friction grip of rim on hub; and, in turn, a positive press fit on the shaft.

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There's More than One Way to Bear Down on Costs

By James B. Scott, President
Welded Products Company, Grand Haven, Michigan

When the backfield runner hits the line and finds a stone wall, he tries to skirt around it for yardage. Likewise, many shops follow these tactics in the tussle for lower costs.

When we can make no further headway in cost reduction with an existing method, we often manage to find new, fresh approaches to the problem. For example:

1. Examine the design. To improve the cast sprocket for a chicken feeder, we used two stampings as shown in Fig. 1. The resultant sprocket operates better because the feed doesn't jam in the teeth. To get the same results with the former design would have cost considerably more.

2. Examine the set-up. We were nip and tuck with competition (another process) on a machine base. By devising an improved clamping and positioning fixture, we speeded up output from 5 bases to 9 bases per day —cut unit cost $2.20 each.

3. Examine the welding procedure. Types and sizes of electrodes . . . amperage . . . A.C. or D.C. . . . these factors are weighed in setting up the procedure for each job. On a recent cold-rolled steel job, we used "Shield-Arc LH-70" electrodes and eliminated pin-holes, speeding up welding and cutting costs.

In all of our efforts to bear down on costs, we find it extremely helpful to have the advice of the Lincoln Welding Engineer, and we use Lincoln Welders and Electrodes practically 100%.

Fig. 1. Changeover of this chicken-feeder sprocket to welded stampings eliminated feed jamming.

Fig. 3. Typical of the welding output of Welded Products Company is this group of engine brackets, fabricated from stampings and shear-cut plate.

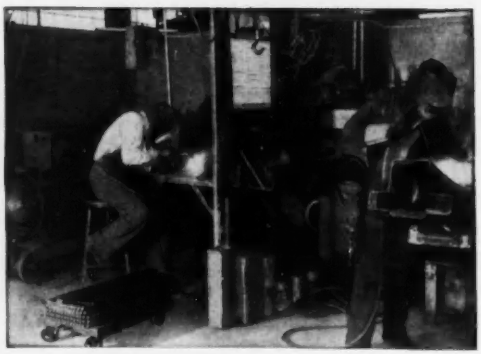

Fig. 2. Two points of attack on welding costs: Left—Duane Brady and James Scott work on the modification of a product design. Right—Ingenuity is applied to the design of fixtures and the planning of welding procedure for each product.

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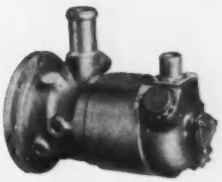
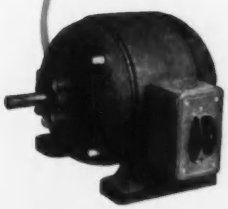
Every Lamb Electric Motor is specially designed for the product or device it is to drive. This means that both electrical and mechanical characteristics are engineered for the exact requirements of the particular application, which often results in savings in space, weight and cost factor.

Special engineering in Lamb Electric Motors assures optimum product performance and efficient, long-life motor operation ... another reason why more and more of America's finest products are being powered with Lamb Electric Motors.



Fuel pump motor having space and weight saving design; suitable for many industrial uses.

THE LAMB ELECTRIC COMPANY
KENT, OHIO



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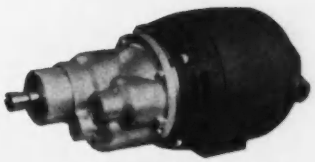

Light-weight universal motor with efficient spur gear speed reducer.

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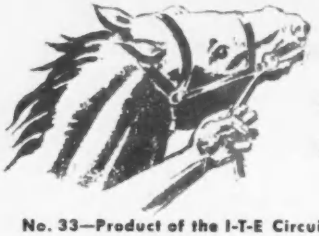
I-T-E

CIRCUIT BREAKER

CHACE BIMETAL "Horseshoes"



Hold the Horses!

No. 33—Product of the I-T-E Circuit Breaker Co. Philadelphia, Pa.

Chace Thermostatic Bimetal controls the horsepower surging through this I-T-E Type "ET" Circuit Breaker. The "horseshoes" are bimetal tripping elements on a common tripping bar. An overload on any of three poles opens the breaker, thus "holding the horses" by relieving the overload condition.

For positive, dependable response Chace No. 6400 Thermostatic Bimetal is specified for the actuating element. It is one of the "6000" Series, specially designed for starters and breakers. This series is graduated with systematic steps in electrical resistivity which correspond to a range of ampere ratings from low to high. Thus, tooling for a complete line of circuit breakers can be greatly simplified in design, using the "6000" Series for the actuating elements.

You build top performance into your product when you specify Chace Thermostatic Bimetal for the thermal element. A complete line of 30 bimetals is available in strips and finished pieces; consult our engineering department for aid in determining which will answer *your* problem in temperature indication, response or control.

W. M. CHACE CO.

Manufacturers of Thermostatic Bimetals

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All materials—all types—large and small—made to specifications, exclusively.

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Take the LATEST ADVANCEMENTS in sealing materials, add FEL-PRO ENGINEERING to adapt them to the specific demands made upon the gaskets used in your products and you have a combination that can MAKE A WORLD OF DIFFERENCE!

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Specifically designed for your product

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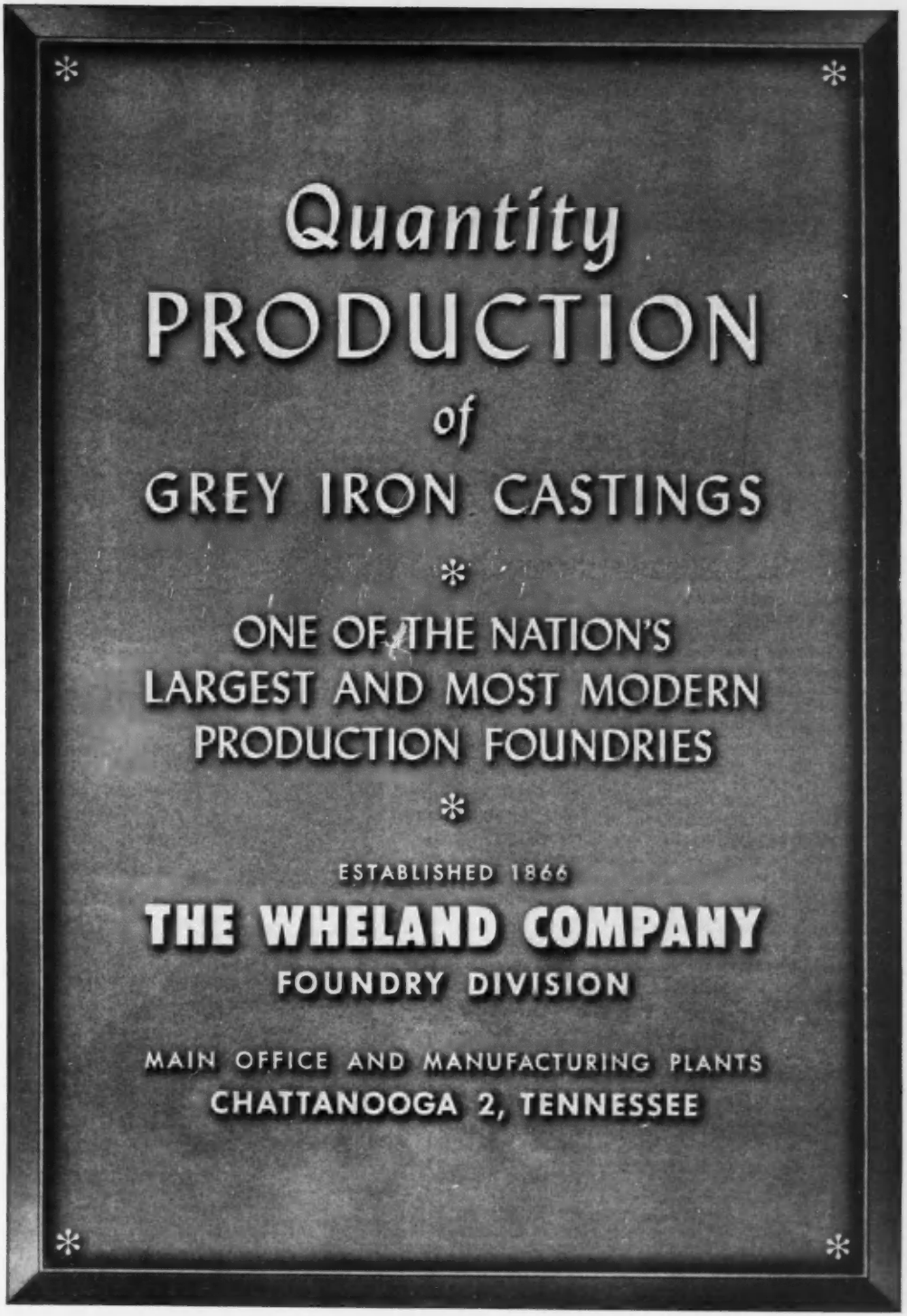
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PRODUCTION
of
GREY IRON CASTINGS
ONE OF THE NATION'S
LARGEST AND MOST MODERN
PRODUCTION FOUNDRIES
ESTABLISHED 1866
THE WHELAND COMPANY
FOUNDRY DIVISION
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CHATTANOOGA 2, TENNESSEE

ANNOUNCING!

A New Line of Sundstrand Panel Mounted Hydraulic Valves - - -

redesigned to
J.I.C. Standards

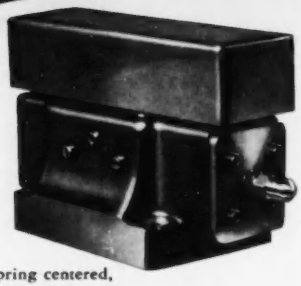
For efficient operation and simplified installation, use these new Sundstrand valves for hydraulic (oil) circuits. They have been redesigned to meet the exacting requirements of the Joint Industries Committee standards but are based on many years of experience in the design and manufacture of hydraulic valves and equipment. Sundstrand valves are available in a range of piping sizes up to ¾" for panel or gasket mounting.

The line of Sundstrand valves now includes the following:

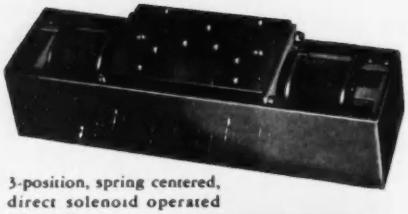
- Relief Valves (High and Low Pressure Series and Non-Adjustable)
- Solenoid Operated Pilot Valves
- 4-Way Valves (Manual, Mechanical, Solenoid Pilot Operated and Hydraulic Pilot Operated)
- Sequence Valves
- Counterbalance Valves
- Cycle Valves
- Blocking Valves
- Loading and Unloading Valves
- Check Valves
- Solenoid Operated Valves

FREE DATA

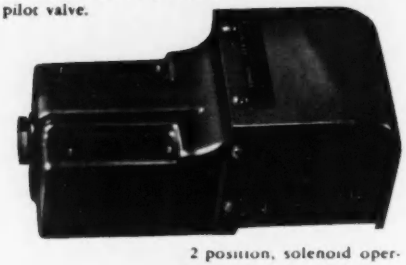
Complete engineering data sheets on the above valves are available. You'll simplify circuit design and improve product performance with these efficient valves. Write for bulletin P-47.



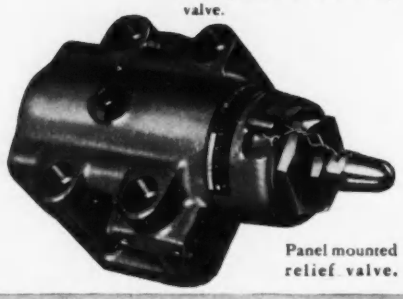
3-position, spring centered, solenoid operated 4-way valve.



3-position, spring centered, direct solenoid operated pilot valve.



2 position, solenoid operated, panel mounted 4-way valve.



Panel mounted relief valve.

SUNDSTRAND MACHINE TOOL CO. ROCKFORD, ILLINOIS, U.S.A.

SUNDSTRAND HYDRAULIC DIVISION

2560 ELEVENTH STREET • ROCKFORD, ILLINOIS

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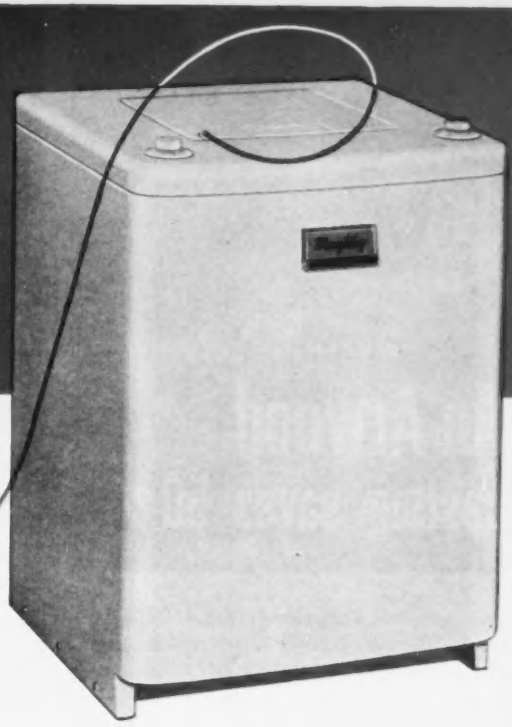
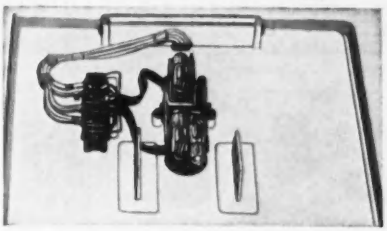
POSITIVE ACTION
every time!



WITH THE HONEYWELL MERCURY *Switch*



One switch cuts off motor when cover is raised, another controls water level, the third causes shut-down in case of an unbalanced load.

THE MAKERS of the all-new Maytag Automatic Washer turned to Minneapolis-Honeywell for the mercury switches needed for three important operations in their radically different product. And each one is relied upon to deliver dependable on-off contact . . . *positive action every time!*

This application may suggest a way in which you can reduce costs and improve performance of *your* product. Honeywell Mercury Switches are tiny and compact . . . are adaptable to unusual mountings. They operate at low angles . . . have no moving parts . . . are sealed against dust, gas and corrosion.

Honeywell Mercury Switches give you greater latitude in product design . . . and greater operating efficiency. Send for New Catalog 1343 for detailed information.

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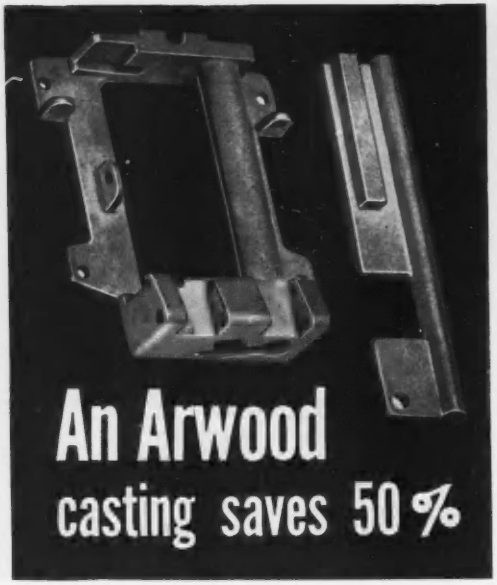
SPECIFY THE HONEYWELL MERCURY *Switch*

MINNEAPOLIS Honeywell — *Mercury Switches* FOR POSITIVE ACTION — BROWN INSTRUMENTS



An Arwood casting saves 50%

Here is a typical example of what ARWOOD precision castings can do. Such results are made possible only by ARWOOD'S years of experience that spells "know-how."

Five parts — 2 stamped and 3 machined — formerly had to be brazed together to make the bronze key guide housing shown at left above. The Lathem Time Recorder Co. reports their costs were reduced 50% when a single ARWOOD Precision Casting replaced the five-part assembly.

The key shown at right is also an ARWOOD Precision Casting which fits the keyway without any adjustment.

ARWOOD Precision Investment Casting is now a tested and important method for producing small intricate parts. It has been the answer to many design and production problems and can be the answer to yours. Write for our booklet, "A Critical Survey of Investment Castings," or ask to have our nearest representative show you samples.

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PRECISION CASTING CORP.

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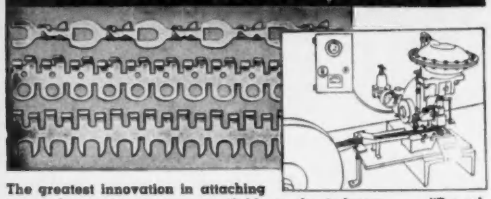
ATTACHED & SOLDERED
in ONE Automatic Operation!



The greatest innovation in attaching terminals to wires is now available to the industry . . . "Pre-soldered" TANDEM TERMINALS! Made in various sizes and types, these remarkable, production-proved terminals (supplied on reels) can be applied at rates up to 1200 per hour by a new Terminal Attaching Machine that cuts off, clinches and solders terminals in one instantaneous operation. Handling of loose terminals, solder and flux are eliminated to reduce costs and boost production on long runs. Standard types available. Send for detailed information, enclose sample of wire and terminal now used Address Dept. B.

For ordinary runs in moderate quantity we continue to produce

SEPARATE TERMINALS for ELECTRIC WIRES

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FELT KEEPS OUT DESTRUCTIVE DUST, RETAINS LUBRICANTS

Today, thanks to felt, farm tractors can plow and harrow in thick clouds of dust without damage. It was not always so; some of the early farm tractors were failures because their working parts were not adequately protected, and dust chewed up the engine, the bearings, the brakes.

Tractor manufacturers now have dust well under control, and American Felt Company is proud to help them, supplying felt for shields and seals that not only keep dust out of working parts, but also retain lubricants. Thus felt serves both industry and agriculture in several important ways. If your product requires protection against dust, dirt, water, or other substances, and must be reliably lubricated, write American Felt Company. Ask for Data Sheet No. 11, "Felt Seals, Their Design and Application", which gives authoritative technical information and includes illustrative samples.

● Bendix Mechanically-operated Farm Tractor Brake is an excellent example of the use of a felt seal to exclude dust. Top, dust shield showing felt seal in place. Bottom, inside view showing the new Centermount construction which eliminates the conventional backing plate.

American Felt Company

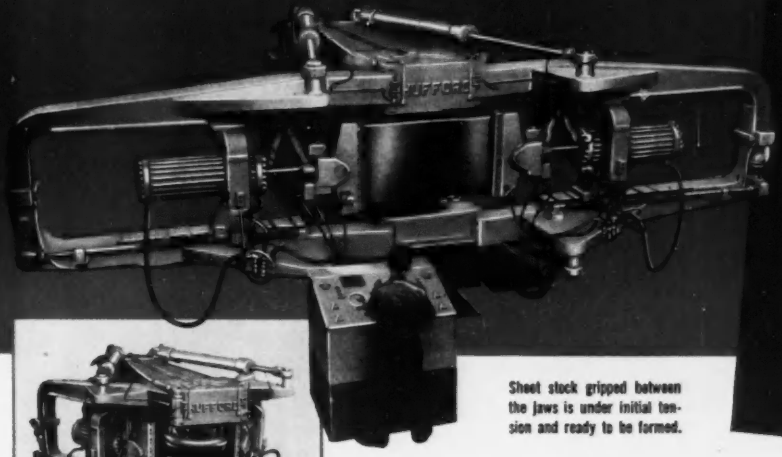
TRADE MARK

GENERAL OFFICES: 36 *Glenville Road,* GLENVILLE, CONN. ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal

VERSATILITY: Plain felt seals are cut by American Felt to your order, with a dimensional tolerance of .005". Laminated felt seals consist of plain felt combined with one or more impervious septums of Hycar.

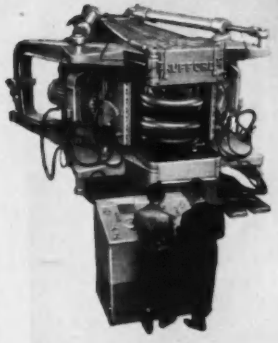
Various combinations are possible, so that a single washer can combine lubrication, lubricant-retention, and sealing against dust, water, etc.

HUFFORD HYDRAULIC STRETCH-FORMING MACHINES



Sheet stock gripped between the jaws is under initial tension and ready to be formed.

Another COST-CUTTING APPLICATION of VICKERS HYDRAULICS



Upon completion of forming operation, sheet is stretched to "set" material to die contour.

A vital factor in the economy, high production and accuracy of Hufford Hydraulic Stretch-Forming Machines is the Vickers Hydraulic Equipment used for both power and control. On the Model 50 machine shown here, the power is furnished by Vickers Balanced Vane Type pumps (two-pressure and single); all the hydraulic control valves are also Vickers. The required versatility is provided, and the control of complex movements is easy and accurate. All controls are handled by "finger touch" levers in the control panel.

Vickers Hydraulics improve the operation of many machines . . . particularly those requiring selectivity of control and adjustment to suit type of work. Any sequence of motions can be provided . . . made automatic if desired. Vickers Hydraulic Equipment is inherently self-lubricated . . . easily protected against overload. By means of interlocks, incorrect or unsafe operation can be prevented. Get in touch with the Vickers Application Engineering Office near you for suggestions on how Vickers Hydraulics can improve your machinery.

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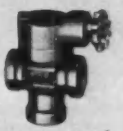
Representative Vickers Hydraulic Pumps and Controls Used on Hufford Stretch-Forming Machines

Two-Pressure Vane Pump

Rotary Pilot Valve



Relief Valve

Lever Operated 4-Way Valve

Solenoid Controlled Pilot Operated 4-Way Valve

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Flow Control Valve

Vane Type Pump (Single)

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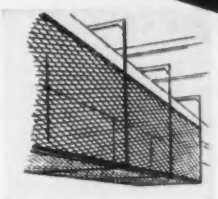
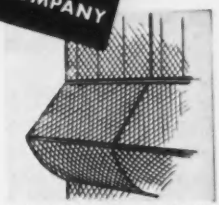
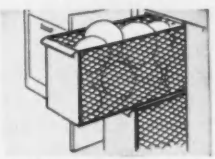


Conveyor Guard that's Lightweight, Efficient



Window Guard Permits Passage of Light and Air

Grille Tray that is Smooth and Sturdy



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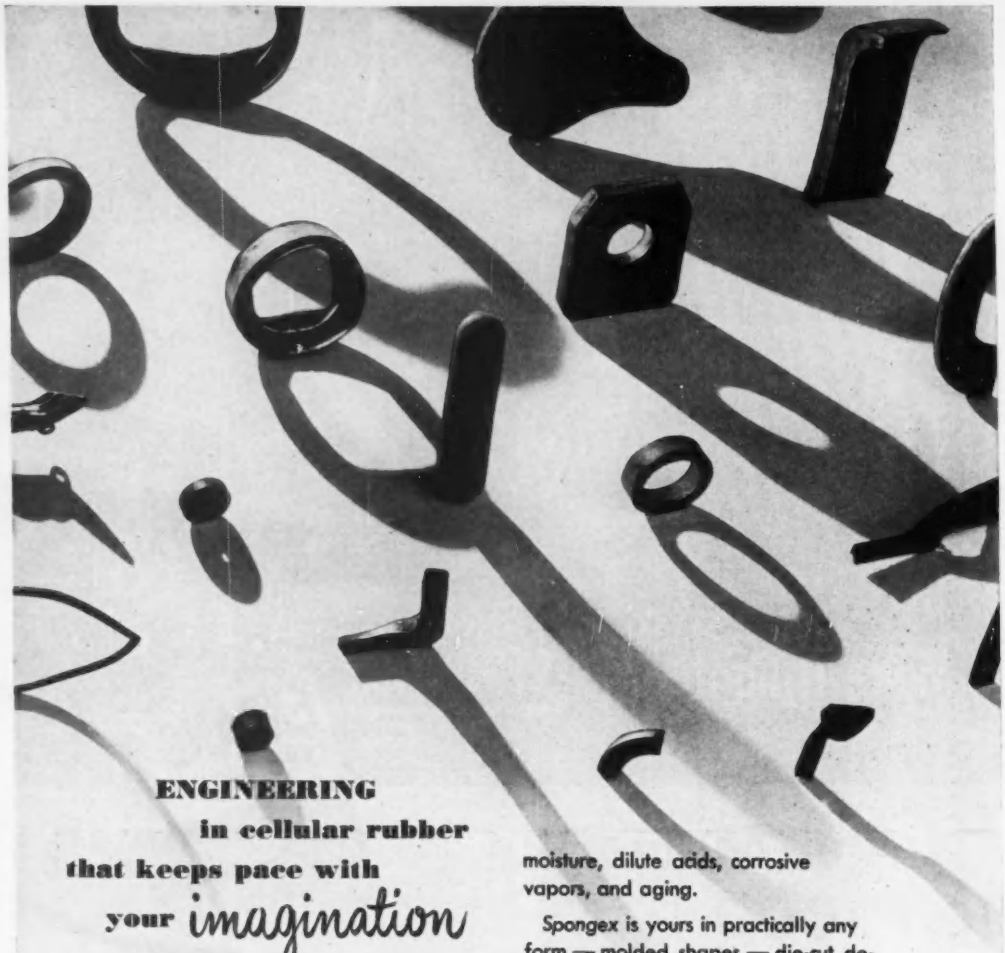

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to combine movement with processing

for EVERY PRODUCT

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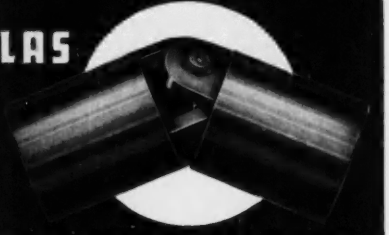
ATLAS



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STRENGTH PLUS ECONOMY

Stubby jaws, heat treated alloy steel and oversized bearings guarantee maximum strength and extremely long life. Low original cost plus negligible replacements produce a saving on every application. Large grease reservoir in center block 1½" size and larger. For full details write Dept. A

GRAY & PRIOR

Makers of Atlas and Vulcan Universal Joints

THE GRAY & PRIOR MACHINE CO., HARTFORD 5, CONN.

In the West: Link Belt Co., Los Angeles, San Francisco, Portland, Seattle, Oakland, Spokane

STRAND

Quality Flexible Shafts

for Remote Control or Coupling

3/16" to 1¼" diameter dependent upon length

2" to 30' length dependent upon diameter

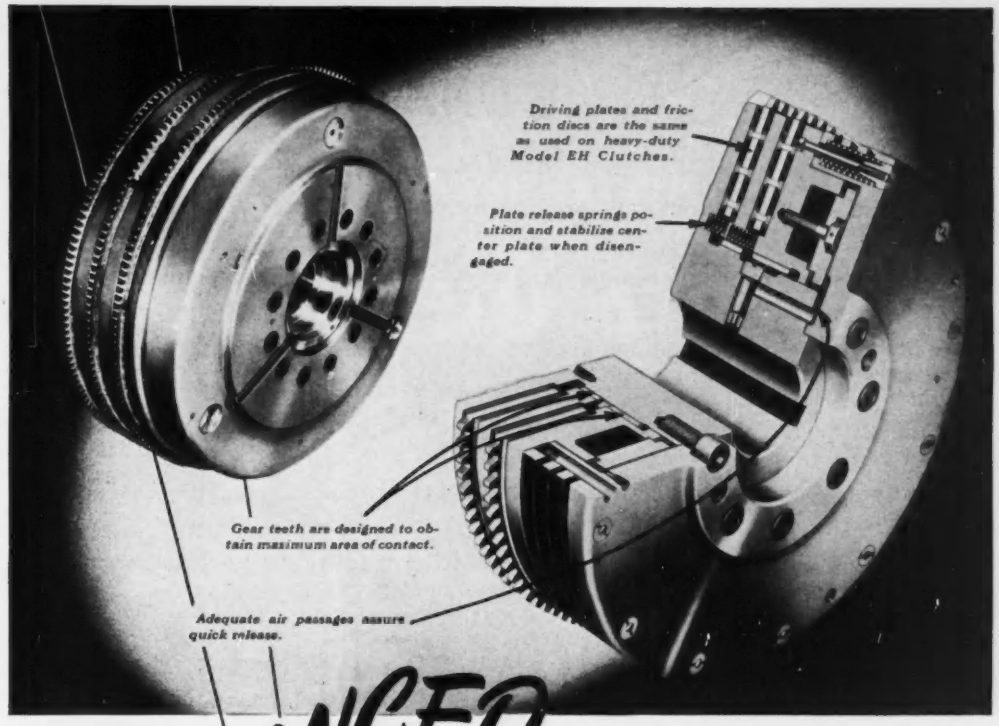
Strand top quality flexible shafts are important to those who are manufacturing quality equipment . . . They give an assurance of dependability, long life, and freedom from breakdowns. Used to couple, for remote control or mechanical regulation in hard-to-reach areas, they have proved successful over a period of years. They are available with or without coupling unit. They can also be had with or without casings. Special couplings made to order.

Write for full information

The Balmar Corporation
M. A. STRAND & CO. DIVISION

STRAND

FLEXIBLE SHAFTS and FLEXIBLE SHAFT MACHINES


Driving plates and friction discs are the same as used on heavy-duty Model EH Clutches.
Plate release springs position and stabilize center plate when disengaged.
Gear teeth are designed to obtain maximum area of contact.
Adequate air passages assure quick release.

BALANCED ...for work, wear, heat

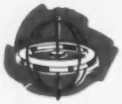
Experience has proved the mechanical proportions of the Twin Disc Models P and PH Air-actuated Clutches to be in proper balance for efficient work, for long wear-life, and to absorb and dissipate heat . . . essential qualities in heavy-duty clutch installations.

Twin Disc Air-actuated Clutches also permit operation by remote control without complicated linkage systems. They require less shaft space, thereby permitting closer shaft bearing center distances. Gear teeth are designed to obtain maximum area of contact. Multiple springs assure quick release and equal distribution of release pressure. Properly installed, these Clutches require no adjustments to maintain the correct pressure on the friction discs . . . an important factor in obtaining longer wear-life. Model P and PH Clutches are available in sizes from 14 to 42″, capacities from 75 up to 1325 hp.

If you have a heavy-duty clutch application requiring operation by remote control, write the Twin Disc Clutch Company for their engineers' recommendations. Ask for Bulletin No. 139-A. TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

BONE TO PICK!

This appliance manufacturer was harassed by vacuum cleaner vibration. "Why not switch to a magnesium fan?" said his designer. "It would balance easier  and reduce the weight of the cleaner . . ." But the boss said he had a bone to pick with magnesium. So they put the idea up to Aluminum Company of America, light metal headquarters. They learned that simple shop practices make handling magnesium no problem.* Fellow manufacturers, they found, use over a million pounds of magnesium every month. They received valuable books on designing and fabricating magnesium, plus technical advice. Now instead of using heavy, hard-to-balance fans like this, they use light . . . uniform American Magnesium Die Castings. They're saving money . . . and their smooth-running cleaner is sweeping the country.

*No change in insurance rates.

These two, free books on magnesium and our broad technical experience can help your products, too. Write Aluminum Company of America, sales agent for American Magnesium Products, 1702L Gulf Building, Pittsburgh 19, Pennsylvania.

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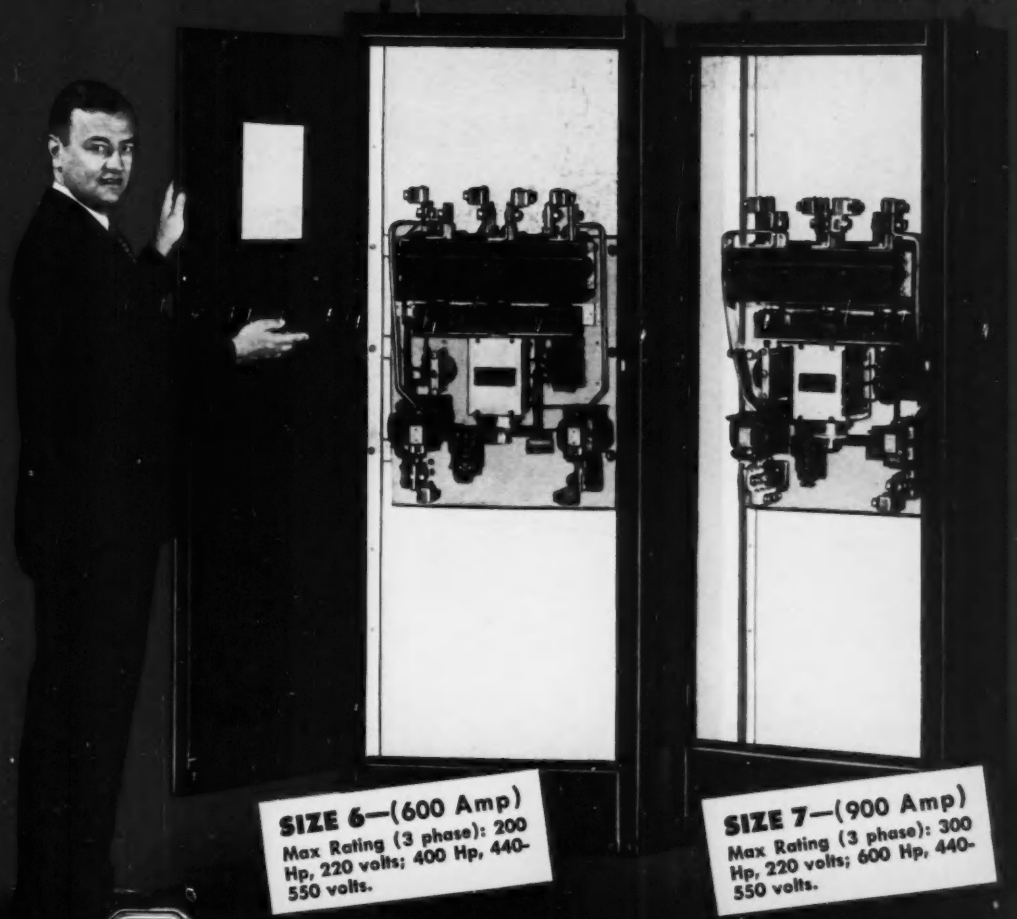
AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

Announcing...

The *NEW* Size 6 and Size 7 SOLENOID Starters



SIZE 6—(600 Amp)
Max Rating (3 phase): 200 Hp, 220 volts; 400 Hp, 440-550 volts.

SIZE 7—(900 Amp)
Max Rating (3 phase): 300 Hp, 220 volts; 600 Hp, 440-550 volts.

A-B Quality

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

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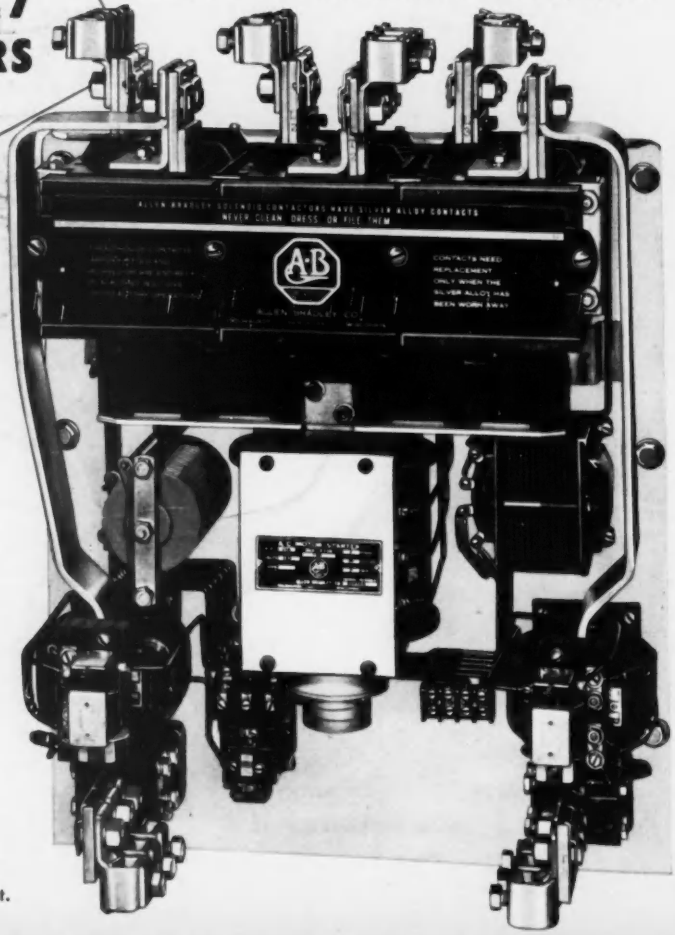
Now- All the Advantages of SOLENOID design

in the NEW SIZES 6 & 7 STARTERS

In years of service, under all operating conditions, the Allen-Bradley solenoid construction has proved its superiority beyond all question of doubt. Now Allen-Bradley has developed Sizes 6 and 7 solenoid starters . . . with all the features that have proved so successful in smaller Allen-Bradley starters. Check its many features.



SILVER ALLOY CONTACTS

The double break, silver alloy contacts never require cleaning or filing—a distinct advantage over conventional copper-to-copper contacts.

SIMPLE, RUGGED CONSTRUCTION

These starters have no pins, pivots, hinges, or complicated mechanisms to cause trouble. The solenoid switch mechanism has only one moving part.

SMALLER SIZE

The open type Size 6 starter is less than ¼ as large as conventional starters, and the enclosed unit takes only 58% of the floor space. Size 7 is even smaller, compared with other starters.

STEEL PANEL MOUNTING

The switch is mounted on a metal base plate instead of a slate panel, and is self insulated. It can be quickly and easily mounted to metal surfaces without additional insulation.

FRONT-OF-PANEL WIRING

All terminals and wiring are readily accessible from the front. There is no back panel wiring.

AVAILABLE IN MANY FORMS

Size 6 and Size 7 solenoid switches can be furnished in 2 pole or 3 pole contactors, across the line starters, reversing switches, reduced voltage starters, and many other combinations where clapper type switches were previously used.

Write for Information

Allen-Bradley Co., 1316 S. Second St.
Milwaukee 4, Wis.

A-B Quality

ALLEN-BRADLEY

SOLENOID MOTOR CONTROL

QUALITY

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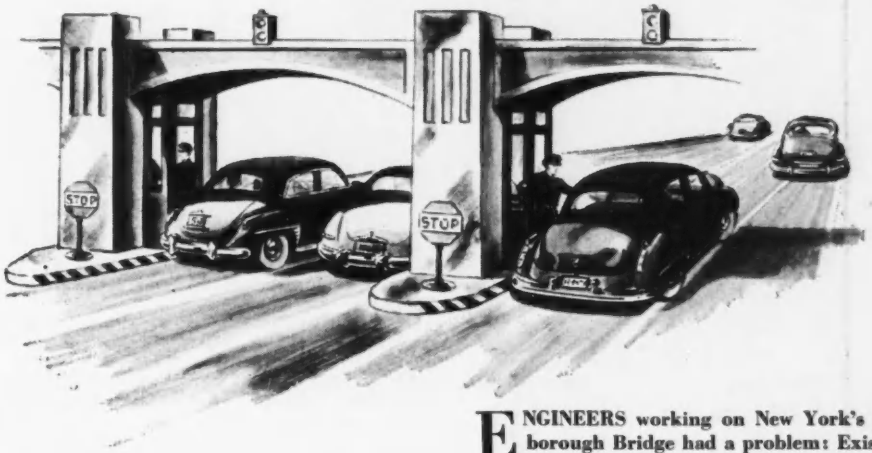
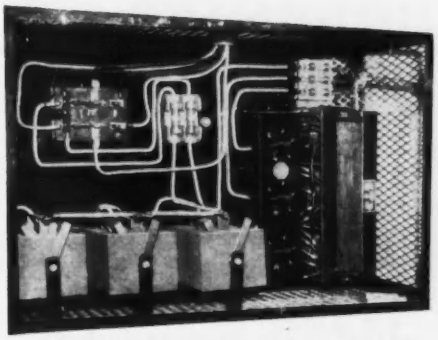
. . . THEN Seletron SELENIUM RECTIFIERS BRIDGED THE GAP!



ENGINEERS working on New York's great Triborough Bridge had a problem: Existing rectifier installations controlling 22 toll lanes were not efficient. . . . They were far too bulky for the current and voltages delivered. . . . They generated too much heat.

The solution? Ralph M. Thompson of the Electronic Signal Company, Williston Park, L. I., to whom the contract was let chose and installed SELETRON *Selenium* Rectifiers built on aluminum . . . and the problem ceased to exist! For SELETRON *Selenium* Rectifiers actually require no more than 1/5th the space needed for the old equipment; they have low internal heat losses, and afford much better voltage regulation.

The Triborough Bridge installation is typical of hundreds of other applications where "job-rated" SELETRON Selenium Rectifiers have paid off in top performance. They are available in a variety of assemblies to cover a wide range of currents and voltages.



INSTALLATION AT TRIBOROUGH BRIDGE, 60 VOLTS OUTPUT, 45 AMPS. CONTINUOUS DUTY, OPERATING 24 HOURS A DAY, 365 DAYS A YEAR.

Perhaps you have a tough rectification problem that SELETRON engineers can solve. Will you write and tell us about it now? Our general catalog is yours for the asking, too. Just address Dept. PS-24.

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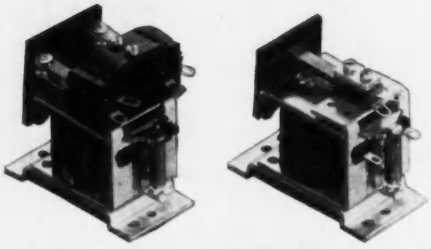

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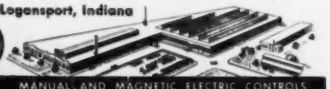
Logansport, Indiana

RBM



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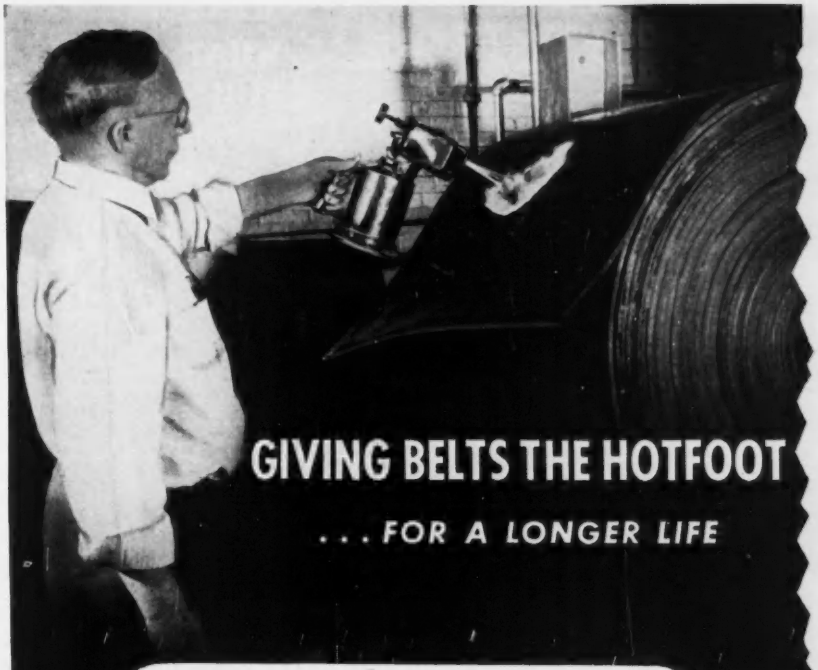

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Red design, clear plastic backed by silver

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Silver design, clear plastic backed by black

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Black design, clear plastic backed by gray

Good Names in
Good Nameplates...

ATTRACTIVE... The design with three-dimensional effect—in any colors—is embedded in lustrous clear plastic. "Crystal Seal" process nameplates are solid shapes of transparent acrylic plastic (Lucite or Plexiglas) with recessed molding in the reverse side. Colors sprayed on the reverse side, using a masking process, bring out the design. Additional color on the back accentuates the contrast and reflects light—or, if there is to be a backlight, the rest of the plate may be left clear.

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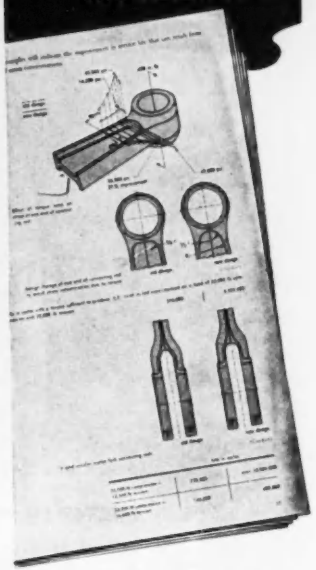

How to avoid the localized stresses which start failure is a basic problem of design. This 72 page booklet analyzes many good and bad features of design. It also deals with problems of steel selection and treatment from the viewpoint of the design engineer —instead of the metallurgist.

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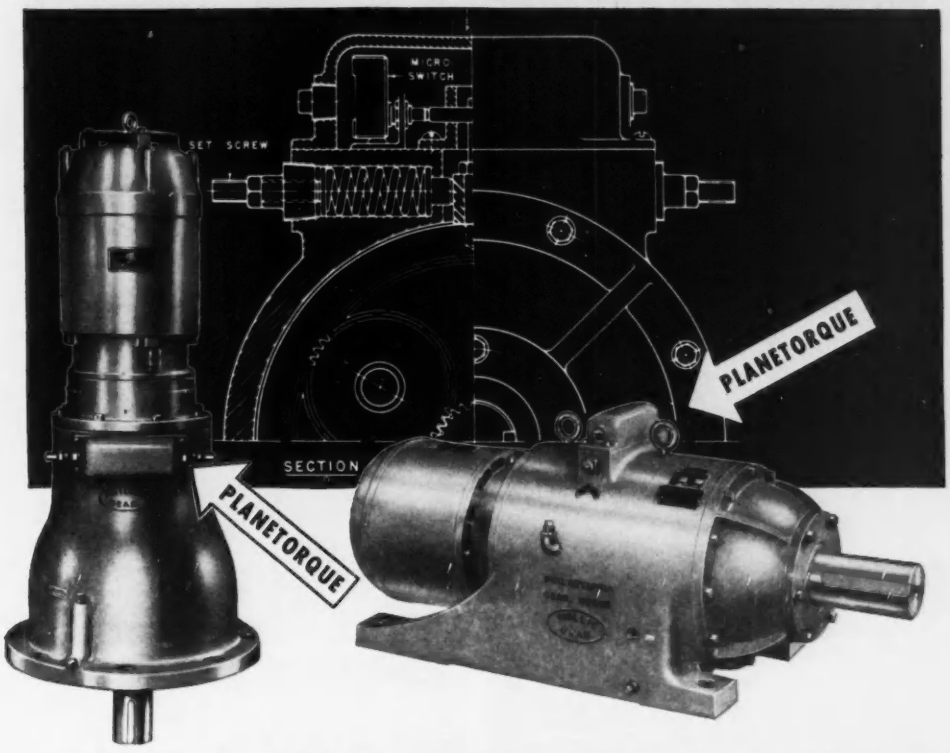


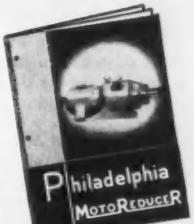
..GIVES INSTANT OVERLOAD PROTECTION

The **PlaneTorque** is a feature that may be supplied with any Philadelphia MotoReduceR *(combined motor and speed reducer)* to protect both the driven machinery and the drive unit from overloads.

By direct mechanical action of the overload, motor current is *automatically and instantly cut off* when a pre-determined limit is reached. This action is quicker than electrical thermal relays provide. (With fuse protection, the fuses must be selected to carry the starting current of the motor; therefore, protection during running period is not adequate.)

The **PlaneTorque** can be cut-out during the starting period merely by holding down the starting button, but will become operative during the running period when the button is released. To restart the **PlaneTorque MotoReduceR** after overload cut-off, *only removal of the excessive load is necessary* . . . a big time saving feature.

For applications such as stoker drives, conveyor drives, mixers, agitators, roll drives, etc. . . . investigate the **PlaneTorque MotoReduceR.**



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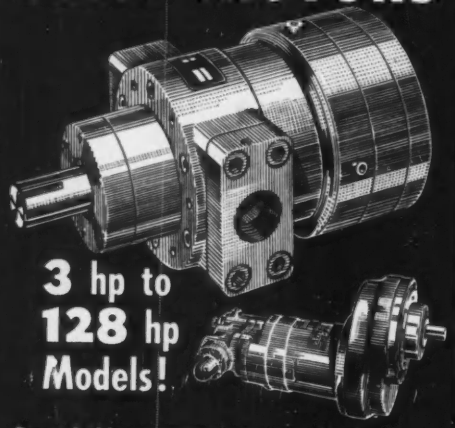

3 hp to 128 hp Models!

Remarkably compact design . . . Stepless speed variation . . . Control valves for rpm regulation . . . Shockproof stop-and-start operation . . . High volumetric efficiency . . . Self lubricating . . . Self-starting from any position.

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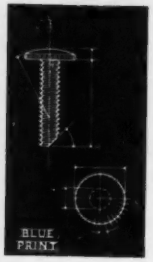

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affects your cash register

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Cost of One Sheet of Polished 18 Gauge 36"x120"* when Thickness May Vary Plus or Minus 10%.

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.048"	60.48 Pounds	$29.18
.047"	59.22 Pounds	$28.57

(Theoretical Weight)

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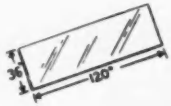

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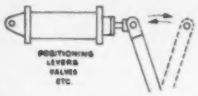

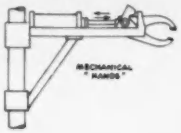

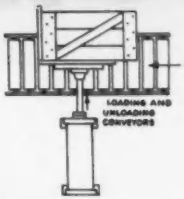

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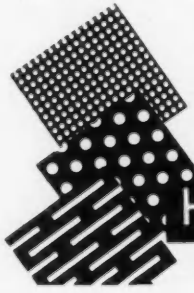

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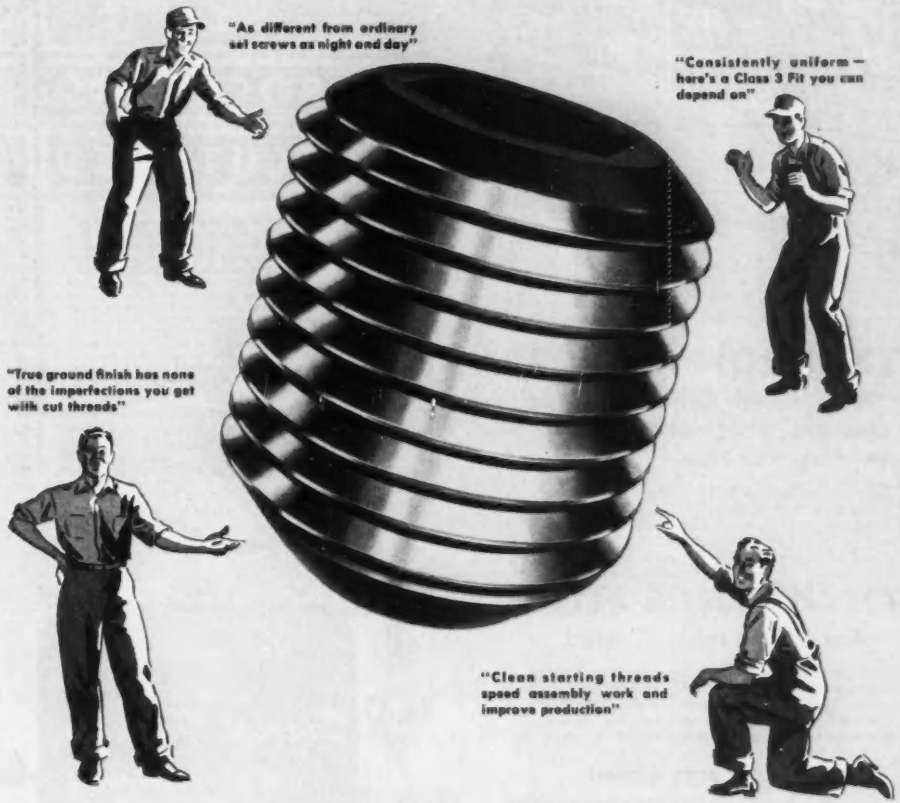
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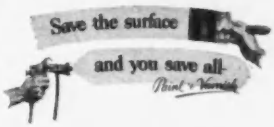

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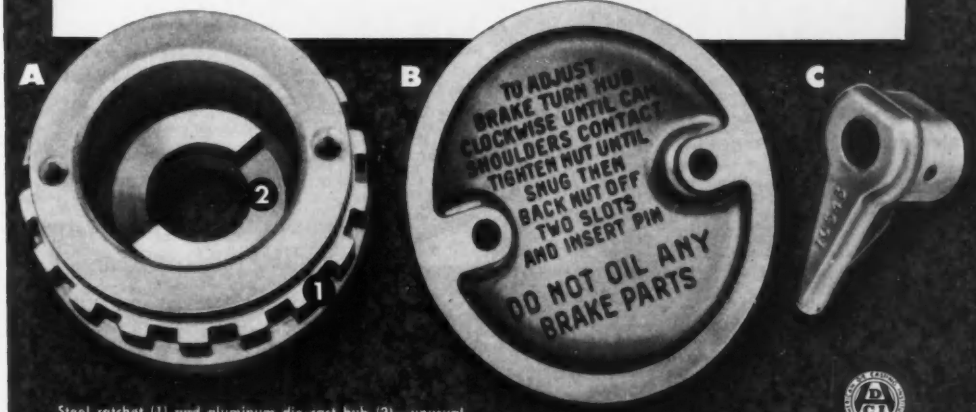

Steel ratchet (1) and aluminum die cast hub (2)—unusual example of an insert larger than the casting which holds it

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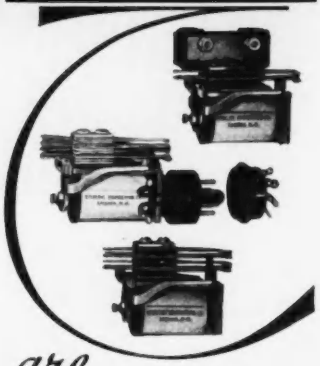

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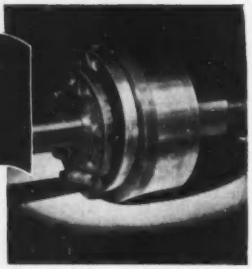

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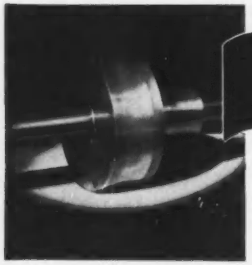

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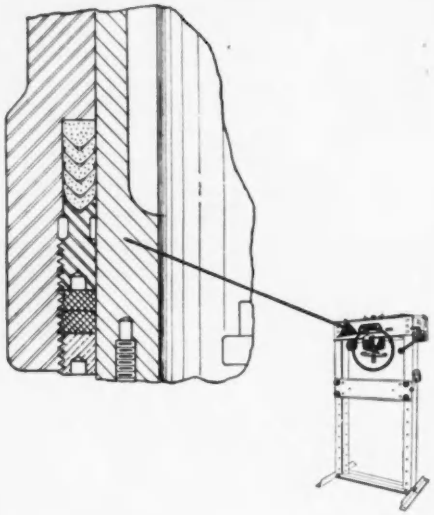

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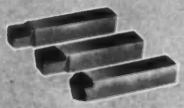

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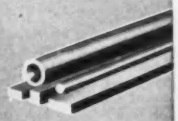

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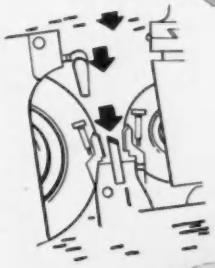

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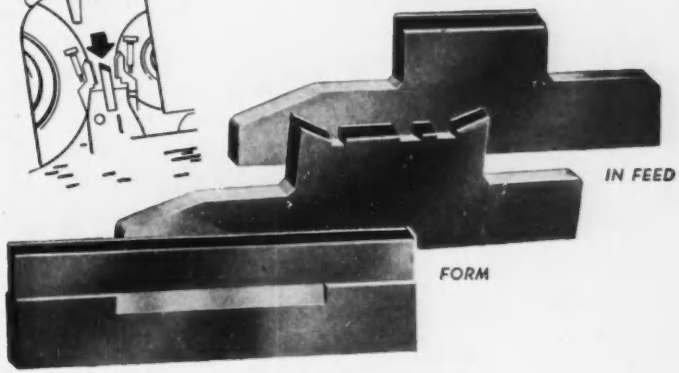

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Provides exceptional timing accuracy where a circuit is to close or open with a time delay. Timing adjustable over wide range.

REPEAT CYCLE

Use where ON-OFF operation is continuously repeated. The ON time and OFF time are each adjustable on the dial.

MULTIPLE CIRCUIT —ADJUSTABLE

Use where several circuits are to close in a predetermined sequence. Time of closing and opening each circuit is adjustable.

MULTIFLEX TIMER

COUNTER

Use for limiting a process to an exact number of operations. The counter contact opens after 1 to 400 electrical impulses as selected on dial. Automatic spring reset.

FLEXOPULSE MICROFLEX COUNTER

Write for catalog Bulletin 291 or send details of your control problems to Eagle for recommendations. Consult Eagle representatives located in the principal cities.

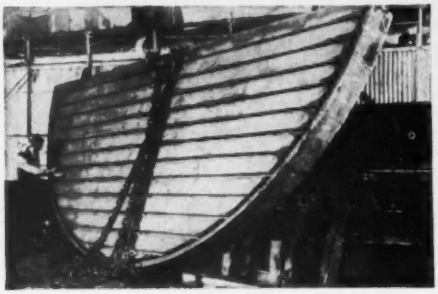
EAGLE Signal Corporation
MOLINE ILLINOIS

LITTLEFORD SPECIAL FABRICATED METAL PARTS AND SUB-ASSEMBLIES

If you are designing new or changing old assemblies, and the problem of small sheet metal parts presents itself—Littleford can fabricate these Parts any size or any shape. Bending, shearing and forming these small items comes through experience, and is an art found in very few fabricating plants. If it's unusual in design, a intricate part of an assembly, no matter how small, send blueprints to Littleford, see how low cost fabrication can cut your costs.

LITTLEFORD
LITTLEFORD BROS., INC.
306 E. Pearl Street, Cincinnati 2, Ohio

SAVINGS START IN THE FOUNDRY



This Advance casting weighs 37,000 lbs. It is a half-round base for a big radial drill. The diameter is 25 ft. Our customer passed many nearer foundries to give the job to us.

It is a rather large undertaking to mold and pour an 18½-ton casting. The job is all the more serious when the casting is a radial drill base with the entire top surface, the rim, and approximately 190 ft. of T-slots to be machined. Such a casting has to be right in every respect to avoid excessive machine-shop cost.

In our founding of *Strenes Metal* cast dies, we have exercised the greatest care to produce sound, accurate, predictable castings. The same techniques are employed on our gray iron and alloy castings which require precise machining. That's why we are doing jobbing work for customers hundreds of miles from Dayton. The freight is insignificant compared to the savings in machining cost.

If you have been getting castings which involve welding or repairing because of blowholes, cold shuts, cracks, sponginess, etc., it will pay you to consult with us. Write, wire, or phone for complete information.

THE ADVANCE FOUNDRY CO.
DAYTON 3, OHIO

ADVANCE CASTINGS
STRENES METAL • ALLOY GRAY IRON • GRAY IRON

MRC
MRC
the M-R-C "Synthe-Seal" bearing
A standard-dimension ball bearing with a removable synthetic rubber seal for keeping out dirt, grit and moisture and for keeping in lubricant.
MARLIN-ROCKWELL CORPORATION, Jamestown, N. Y.

HOW to SAVE DOLLARS with BERYLLIUM-COPPER

Here is an opportunity to improve your product and—at the same time—cut costs. Valuable guides for the most economical use of age-hardening beryllium-copper, based on years of research and practical experience, are yours for the asking. Write TODAY for any or all of the following reprints.

Economies Result When Parts Are Designed for Beryllium-Copper

Case histories of successful designs where specific properties of beryllium-copper were used for best performance at lowest cost. ☐

Beryllium-Copper as a Spring Material

Technical data covering elastic strength, resistance to corrosion and fatigue, conductivity and other properties which make beryllium-copper ideally suited for spring design. ☐

Production of Metal Diaphragms

Helpful facts about beryllium-copper diaphragm design together with recommended tooling, heat-treating and testing procedures. ☐

How to Machine Beryllium-Copper

An up-to-date report summarizing current machining practice including proper tools, feeds, speeds and cutting fluids. ☐

How to Heat Treat Beryllium-Copper

Suggested techniques for low-cost heat-treating to meet specific property requirements without expensive equipment. ☐

In addition to the above literature, we have other data available. Or if you have a design problem, send us full information with a drawing or sample of the part.

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The BERYLLIUM CORPORATION

Dept. 6, Reading 2, Pa.

MOTOR DATA COORDINATED

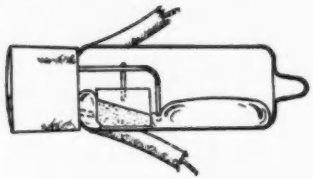
Something new and valuable has been added to McGRAW-HILL PRE-FILED ELECTRICAL CATALOGS, long a standard source of product information: That something is the 16-page section devoted to NEMA MOTOR AND GENERATOR STANDARDS. This combination makes available in one unique volume information filed by manufacturers of motors and the authoritative Motor Standards sponsored by the National Electrical Manufacturers' Association.

When you want information about Motors, always refer to McGRAW-HILL PRE-FILED ELECTRICAL CATALOGS. Nowhere else can you find such coordinated data at your fingertips.

If PRE-FILED ELECTRICAL CATALOGS is not available for buying reference at your plant, write to McGRAW-HILL CATALOG SERVICE, 330 West 42nd Street, New York 18, N. Y. There is no charge to qualified users.

POWREX MERCURY SWITCHES

Engineered for Durability



Long life and ease of operation make POWREX switches ideal for designed-in service.

Complete range of designs and sizes up to 30 amperes.

Available from Stock

MAIL THIS FORM TODAY!

POWREX SWITCH CO.
34 Pleasant St., Watertown 72, Mass.

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Company .....

4 REELS OF VEELOS *replace* 316 SIZES OF ENDLESS V-BELTS

Write for your VEELOS Data Book... it's free and it's full of engineering, measuring and installation information on Veelos. Everyone interested in power transmission should have a copy for ready reference.

MANHEIM MANUFACTURING & BELTING CO.
MANHEIM, PENNSYLVANIA

"I DON'T like to tie-up operating capital . . . who does? That's why, in our plant, we use Veelos on all v-belt drives. In the old days our stockroom was a dangling mess of endless v-belts. But no more. Now, on wall space only sixteen inches square, hang 4 reels of Veelos: Those 4 reels in O, A, B and C widths take care of *all* our v-belt needs. Simple story sure, but a sound, practical picture of saving money the Veelos way."

And there are other advantages beyond the saving of inventory when you standardize on Veelos, the adjustable v-belt. Veelos is easy to install—just measure and couple. You never dismantle outboard bearings to replace Veelos v-belts—that keeps machine downtime at rock bottom. Uniform operating tension, smooth, vibrationless power delivery and long life are more plus values from Veelos.

ADJUSTABLE TO ANY LENGTH • ADAPTABLE TO ANY DRIVE

VEELOS
THE LINK
V-BELT

Veelos is made in all standard sizes; fits all standard v-belt grooves. Packaged on reels in 100-foot lengths. Sales engineers in principal cities; over 350 distributors throughout the country. Veelos is known as VEELINK outside the United States.

Here's practical design information on the . . .

Generation, use, control and transmission of oil hydraulic power

DESIGNERS, design and service engineers—everyone engaged in oil hydraulic work—will find this new book a valuable working tool covering the very latest practice in hydraulic components, oil circuits and applications.

Stressing the development, theory and application of oil hydraulics, it discusses all aspects of fluid mechanics as applied to oil under pressure . . . its flow characteristics, viscosity and behavior in hydraulic machinery. The generation of oil hydraulic power is discussed in detail, as is its utilization in rotary and reciprocating motors, its control by suitable valves, and its transmission through piping, tubing and fittings. A few representative oil hydraulic-powered and controlled machines are illustrated and described.

OIL HYDRAULIC POWER
AND ITS
INDUSTRIAL APPLICATIONS

By Walter Ernst; Hydraulic Consulting Engineer; Vice-President and Director of Engineering, The Commonwealth Engineering Co.; formerly Director of Engineering, The Hydraulic Press Mfg. Co.

366 pages, 6x9, 275 illustrations, $6.00

Reflecting practical engineering experience, this guide covers actual detailed design and working theory of hydraulic pumps, valves, etc. It illustrates and describes a number of elementary and complex circuits, and takes up the construction and operation of rotary and reciprocating motors. Piping, tubing, flanges, etc., are discussed in detail, as are pressure, volume and directional controls. The author presents important data on the storage and intensification of hydraulic power . . . shows how to put hydraulic components together into working circuits . . . and carries out a number of actual designs and calculations. Many practical hints on installation, specification and connection of units are given.

Packed with scores of helps like these:

- **how to design heavy-duty gear pumps**
- **how to combine two pumping units**
- **how to design servo-motor controls**
- **how to construct horizontal - plunger - type motors**
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- **how to apply oil hydraulic power to oil-pressure presses, milling machines, drilling and boring machines, and many others**

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1/50 TO 1 H.P. @ 1750 R.P.M.
Compact, one-piece construction. Convenient for small equipment. 15° rated torsional deflection gives excellent vibration isolation.

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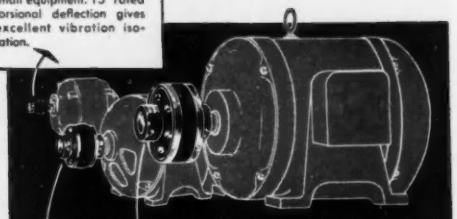
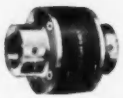


LORD Flexible Couplings
1/50 to 100 h.p.



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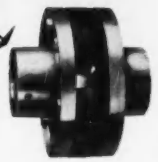


20 TO 100 H.P. @ 1750 R.P.M.
The answer to destructive torsional vibration from high power drive systems. Removable flexing joints enable replacement without moving equipment. 3° deflection.

The development of Lord M.H.P. Couplings completes the line of Lord Flexible Couplings from 1/50 to 100 h.p. and greatly extends the possibilities for product improvement and customer appeal.

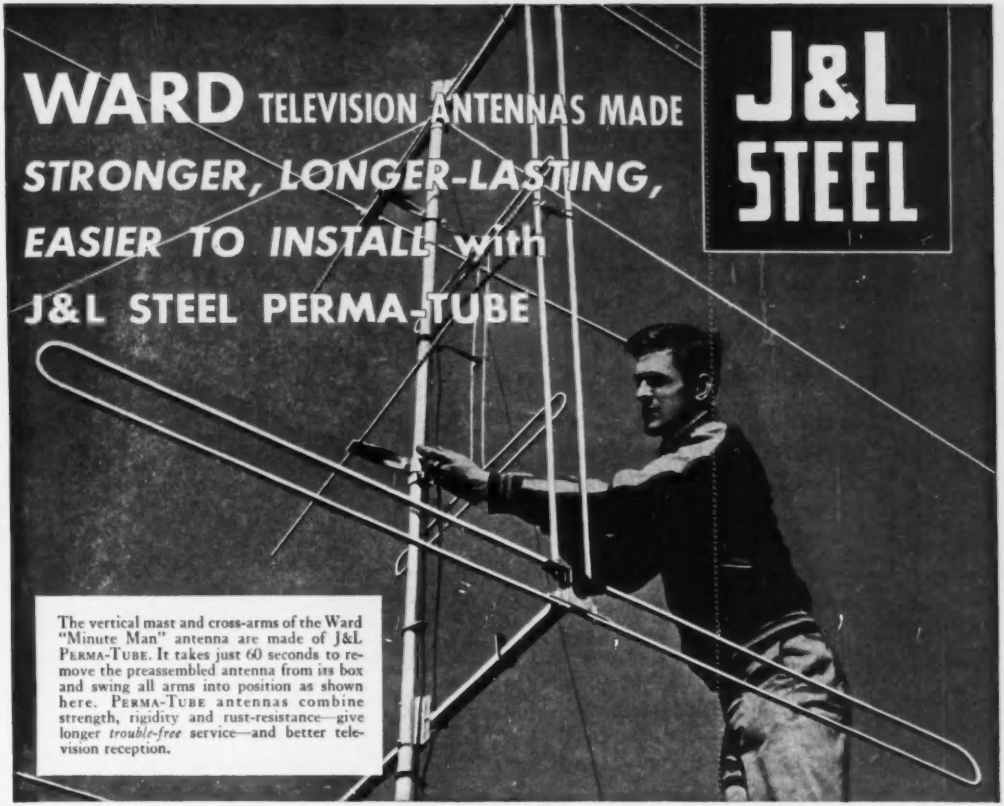
Large torsional deflection assures an even flow of power from motor to driven equipment. The Neoprene flexing element is oil resistant . . . there are no bearing surfaces to chafe . . . no lubrication is required. Lord M.H.P. Couplings are permanently quiet . . . they are unaffected by sand, emery, or other abrasives.

Simple construction and a high degree of accommodation to angular and parallel misalignment reduce assembly costs. It will pay you to investigate the advantages of incorporating Lord M.H.P. Couplings in your product design.

Bulletin 201 describes the complete line of Lord Flexible Couplings. See our bulletin in Sweet's 1949 File for Product Designers or write for Bulletin 900 showing Lord Vibration Control Mountings and other Bonded Rubber Products.

LORD MANUFACTURING COMPANY • ERIE, PA.
Canadian Representative: Railway & Power Engineering Corp. Ltd.

LORD Vibration Control Systems


WARD TELEVISION ANTENNAS MADE
STRONGER, LONGER-LASTING,
EASIER TO INSTALL with
J&L STEEL PERMA-TUBE
J&L STEEL
The vertical mast and cross-arms of the Ward "Minute Man" antenna are made of J&L PERMA-TUBE. It takes just 60 seconds to remove the preassembled antenna from its box and swing all arms into position as shown here. PERMA-TUBE antennas combine strength, rigidity and rust-resistance—give longer *trouble-free* service—and better television reception.

PERMA-TUBE may be used for many applications where strength, rigidity, rust-resistance, and attractive appearance are necessary.

By using the new exclusive rust-resisting J&L PERMA-TUBE for the vertical mast and cross-arms in the "Minute-Man" series of television antennas, Ward Products Corporation, Division of the Gabriel Company, Cleveland, Ohio, builds-in the following advantages:

1. **Greater structural rigidity with smooth, attractive appearance. Greater strength to resist ice loads.**
2. **Clearer, steadier, television reception. Less vibration from wind.**
3. **No mechanical seam in Perma-tube to invite rust which would reduce the torsional strength.**
4. **Ease and speed of installation . . . at less cost.**

J&L PERMA-TUBE is a light-wall, electricweld steel tubing, coated inside and out with an exclusive plastic-type, weather-resistant finish. PERMA-TUBE can be furnished: bent . . . expanded . . . flanged . . . swaged or fluted.

J&L PERMA-TUBE for television antennas, *costs less than any other tubing with comparable strength, rigidity and rust-resistance.*

J&L PERMA-TUBE is not only applicable to television antennas, but also wherever strength, rigidity and rust-resistance are important. It is available in all regular sizes and shapes of J&L Electricweld Tubing and in lengths up to 10 feet. Return the coupon TODAY for complete information on this new J&L product.

Jones & Laughlin Steel Corporation
409 Jones & Laughlin Building
Pittsburgh 19, Pa.

Please send me complete information on the new J&L STEEL PERMA-TUBE mechanical tubing.

Do you recommend PERMA-TUBE for _____?

NAME _____

COMPANY _____

ADDRESS _____

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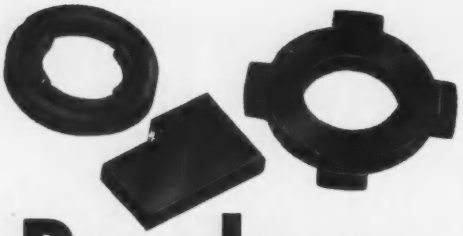
From its own raw materials, J&L manufactures a full line of carbon steel products, as well as certain products in OTISCOLOY *and* JALLOY (*hi-tensile steels*).

PRINCIPAL PRODUCTS: HOT ROLLED AND COLD FINISHED BARS AND SHAPES • STRUCTURAL SHAPES • HOT AND COLD ROLLED STRIP AND SHEETS • TUBULAR, WIRE AND TIN MILL PRODUCTS • "PRECISIONBILT" WIRE ROPE • COAL CHEMICALS



Purebon

solves many problems

caused by sliding or rotating parts which are difficult or impossible to lubricate

A constantly increasing stream of problems are facing engineers and designers today involving sliding or rotating parts where lubrication is difficult or impossible. For such applications, Purebon, the mechanical carbon, is often the ideal answer. Typical applications are seal rings, bearings, pistons, piston rings, pump vanes, valve seats, meter discs, and a host of similar items. Purebon comes in a wide variety of grades. It is strong, tough, readily machineable and in many cases can be molded directly to size.

Bulletin No. 482 tells the complete story of Purebon. Write for your copy today.

PURE CARBON CO., INC.
448 HALL AVE. ST. MARYS, PA.

SPEED PRODUCTION WITH MIDLAND WELDING NUTS

U. S. PAT. No. 2054189

¼" F-2004

⅜" F-2008

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½" F-2012

⅝" F-2016-A

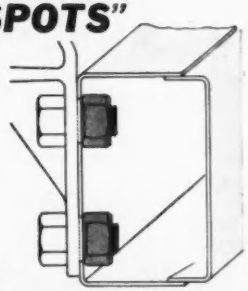
RAPID ASSEMBLY and accuracy are assured by the Midland Welding Nut because it is *self locating*. Collar on nut locates into pierced hole in receiving member. Eliminates use of locating pins or fixtures.

PARTICULARLY USEFUL IN "BLIND SPOTS"

The Midland Welding Nut in concealed and hard-to-reach places, as shown here, speeds up production materially.

Midland Welding Nuts offer numerous other time-saving and cost-saving advantages.

Write, wire or phone us for complete information.



The MIDLAND STEEL PRODUCTS CO.

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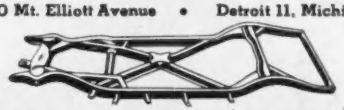
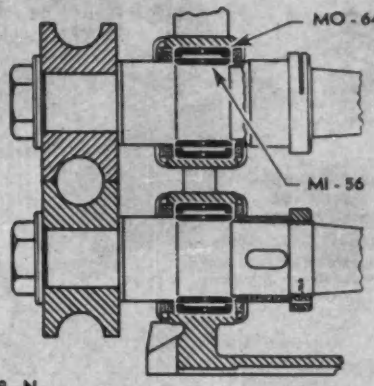
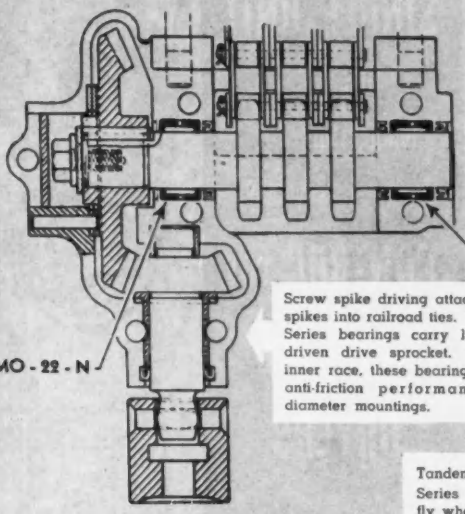


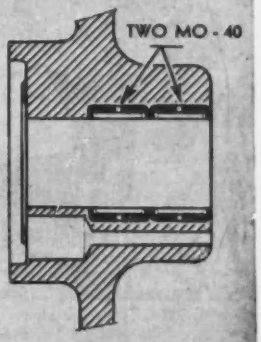
WORLD'S LARGEST MANUFACTURERS OF AUTOMOBILE FRAMES—

In this continuous tube welding machine, MULTIROL SE Series bearings carry the tube forming load as journal bearings. To support the heavy load, shafts are kept large, but journal dimensions are held to the minimum — reduces cost.

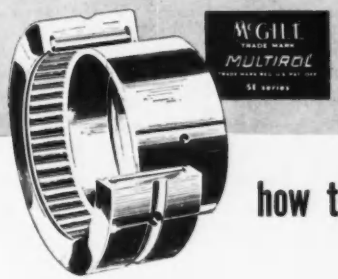




Screw spike driving attachment screws spikes into railroad ties. MULTIROL SE Series bearings carry load of chain driven drive sprocket. Used without inner race, these bearings provide full anti-friction performance in small diameter mountings.



Tandem mounting of MULTIROL SE Series bearings on a punch press fly wheel. Bearings are mounted in pairs for even distribution of extra heavy load and easily carry impact of shock load every time clutch is engaged. Shaft serves as inner race permitting more compact mounting.



how to anti-frictionize for improved performance

THE MULTIROL WAY

The efficiency of any machine can be raised when plain friction bushings are replaced with MULTIROL SE Series full type roller bearings. Speeds are easily increased and accuracy improved over a longer expected bearing life.

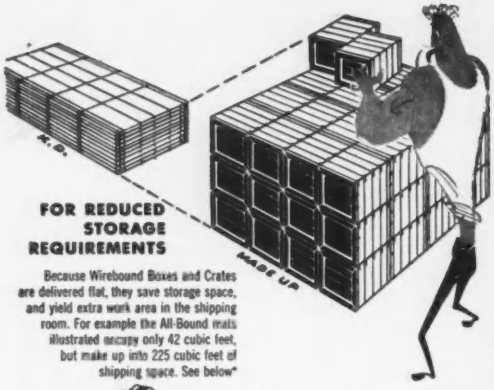
The MULTIROL Way requires less maintenance because lubrication can be provided through either the shaft or housing — oil holes and channels in both outer and inner — no need for constant oiling — no danger of dry journals when lubrication is temporarily neglected.

Costs less too. Ordinarily large housings can be reduced to accommodate the MULTIROL Bearing minimum OD for a given shaft size and load capacity. Remember also that eliminating friction saves on power imput.

MULTIROL SE Series bearings are anti-frictionizing machines in all industries. The above drawings illustrate typical examples of improved bearing applications. We will gladly make engineering recommendations for you. Write today for helpful MULTIROL Bearing literature.

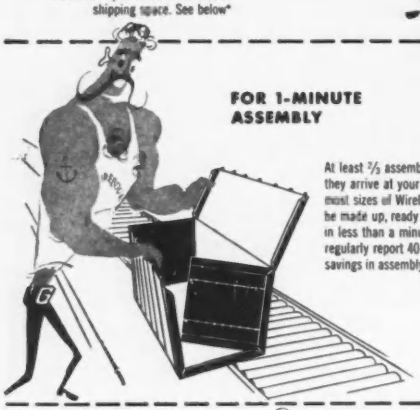
Address McGill Manufacturing Co., Inc., 201 N. Lafayette Street, Valparaiso, Indiana, for your copy of MULTIROL Bulletin SE-48.

McGILL
TRADE MARK
precision bearings



FOR REDUCED STORAGE REQUIREMENTS

Because Wirebound Boxes and Crates are delivered flat, they save storage space, and yield extra work area in the shipping room. For example the All-Bound mats illustrated occupy only 42 cubic feet, but make up into 225 cubic feet of shipping space. See below*



FOR 1-MINUTE ASSEMBLY

At least ⅔ assembled when they arrive at your plant, most sizes of Wirebounds can be made up, ready to pack in less than a minute. Users regularly report 40-50% savings in assembly time.*

FOR BETTER, SAFER STACKING

The versatility of the Wirebound principle—the strength of steel combined with thinner wood—permits variation of wire gauges, staple spacing, battens and cleats to provide safe structural strength for large and small containers to meet all warehousing requirements. Note*

USE Wirebound **BOXES & CRATES** FOR LOWER TOTAL SHIPPING COSTS

60 Wirebound Plants throughout the United States

***Send for this free book!** Explains in detail Wirebound principles, advantages, features and describes how Wirebounds are designed to suit every size and shape of product. Mail coupon today.*

Wirebound Box Manufacturers Assn., Room 1830 Borland Bldg., Chicago 3, Ill.

☐ Send Booklet of Product Information ☐ Send a Sales Engineer

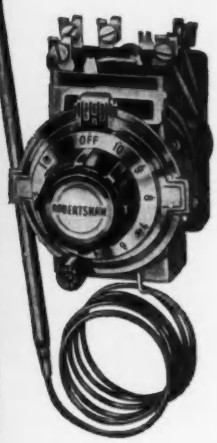
NAME

COMPANY ADDRESS

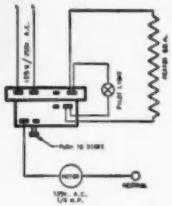
CITY ZONE STATE

OUR PRODUCT IS

Robertshaw SINGLE UNIT time, temperature and motor CONTROL for LAUNDRY DRYERS



H-15



1 Set temperature.
2 Push starting button to energize heater and motor.
3 When temperature is reached, heater is automatically disconnected and motor continue to run.
4 After cooling approximately 20°F., motor cuts off automatically.

Combines heating and timing controls in a single unit. Handles both motor and electrical heating circuits. Amount of moisture and weight of clothes scientifically determine length of time dryer operates to automatically produce degree of dryness desired by operator. Control cuts heat switch when correct internal temperature is reached, but motor continues to run until all stored heat in drying chamber has been utilized.

Economical to install — produces maximum operating efficiency of appliance. Write for information.

Visit Booth D, American Gas Association Combined Gas Exhibit at the National Hotel Show

Robertshaw

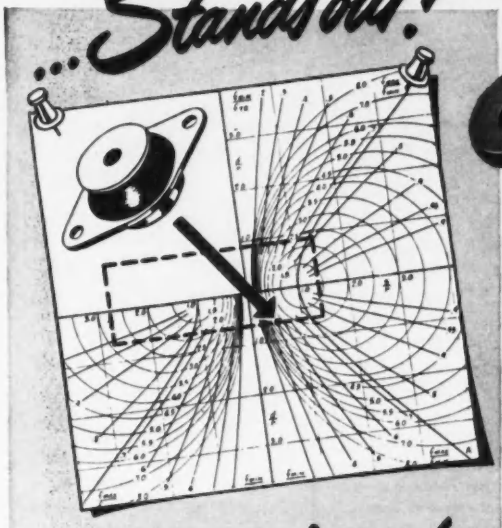
THERMOSTAT DIVISION
ROBERTSHAW-FULTON CONTROLS COMPANY
YOUNGWOOD, PENNSYLVANIA

Here's why

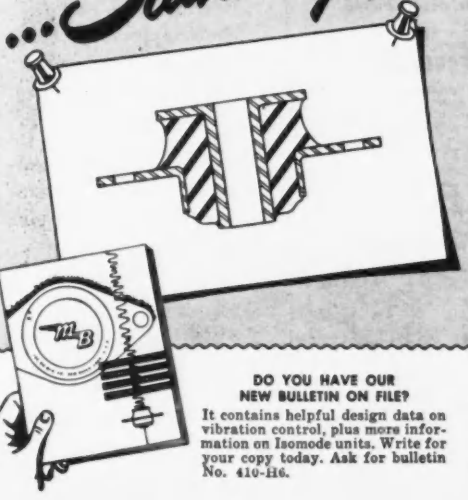
VIBRATION ISOLATION

with MB's ISOMODE* UNITS

...Stands out!



...Stands up!



FIRST OF ALL, Isomode units have equal spring rates in all directions—which means equal absorption of vibratory motions no matter what their direction. Thus, in suspending your product to damp major vertical vibrations, you're not apt to find lateral or angular motions still giving you trouble. This feature also makes designing easier, since you can install Isomode units at any angle!

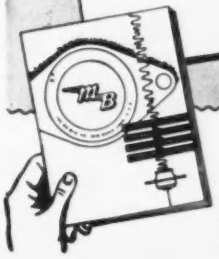
WHERE you put isolators affects results too. How do *you* locate them—by trial, by involved calculations? There's a better way! Simply project your product on the Isomode Design Chart* and find *optimum* points almost by inspection! You'll find that with the right isolator at the right point, you can smooth many a serious "shake" into a negligible ripple.

(**Yours for the asking—write us*)

FAILURE OF A MOUNT can void your most carefully designed suspension. But you needn't ever worry about the Isomode unit's durability. Notice the construction which allows the core to be balanced between compression and shear. Not only does this provide a stronger, more stable mounting, but also greater capacity to withstand shocks with smaller, lighter units.

THIS TYPE 5 ISOMODE unit is one of many MB mounts available to you. You can see why they are specified for the tough problems — and how they've managed to run up extraordinary service records on well-known products. If you have a vibration problem, let us show you how to eliminate it with an MB suspension.

*Trade Mark Reg. U.S. Pat. Off.



DO YOU HAVE OUR NEW BULLETIN ON FILE?

It contains helpful design data on vibration control, plus more information on Isomode units. Write for your copy today. Ask for bulletin No. 410-H6.

THE MB MANUFACTURING COMPANY, Inc.

1060 State Street, New Haven 11, Conn.

BRUNING BW WHITEPRINTER 93

VOLUMATIC MODEL

Now *all* your departments can handle their copying jobs with a single versatile machine: the Bruning Whiteprinter, Volumatic Model 93. This brand new machine at last provides you the necessary volume and high speed (up to 105 sq. ft. per minute). At the same time, through simpler operations and less wastage, it reduces copying costs.

The Volumatic produces sharp, highly legible copies of engineering drawings, documents, or *anything* that is printed, drawn, written, or typed on a translucent medium. It copies charts, plats, letters, invoices, financial reports—and many other items. Its operation is so simple that a girl can learn to run it in less than an hour.

The Volumatic takes cut sheets or roll stock with equal facility. It produces sharp BW Prints from post card size up to 42 inches wide and of unlimited length. You can have light, medium, or card-weight BW Prints; BW Prints on tinted stocks; BW Prints on film or cloth; or BW Prints with colored lines. BW Prints are delivered front or rear, neatly stacked.

Other Bruning Products you should know about

Drafting Machines • Sensitized Papers & Cloth Tracing Papers • Erasing Machines • Drafting Room Furniture • Slide Rules Surveying Instruments and many others.

CHECK THESE BW ADVANTAGES

No vents or exhaust fans: The Bruning Model 93 is completely odorless . . . can be used anywhere in the office without the slightest offense.

Built-in constant wattage transformer: Protects lamp against voltage fluctuations. Assures longer lamp life, more uniform prints, savings on materials.

No plumbing connections: There are no pipes to connect, no water to supply or drain away. The Model 93 is mounted on casters, is moved where needed.

Uniform developing: Both sides of the print receive a thin, measured film of BW Developer solution at once. Assures flat prints, never under- or over-developed.

Send today for full information. Let us send you a file of literature describing the new BW Volumatic Model 93 and other Bruning Whiteprinters, and the BW Mediums you can use with them. See for yourself the extreme versatility, economy, and speed of these machines. There is no obligation.

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PLASTICS *as* ENGINEERING MATERIALS

This PRODUCT ENGINEERING reprint offers valuable data on plastics as attractive engineering materials. It discusses the advantages plastics offer in weight savings, lower costs, moisture and chemical resistance, toughness and abrasion resistance, and many other qualities that are the everyday concern of any design engineer specifying plastics in his products.

This informative report covers the functional use of plastics in the following applications:

- Heavy duty electrical equipment
- Heavy production machinery
- Motor parts
- Bearings and gears
- Home appliances
- Hydraulic components
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Reprints in 24-page booklet form are available at 25¢ each from the Reader Service Department.

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You Can't Cut the Corners that Count!

Here in Richmond, Indiana, we're doing just as you are doing. We're trying to cut corners, reduce costs, produce more good gears for less.

But in gear-making, as in baseball, cutting some corners is "out." We won't stay in business making low-cost gears that produce high-cost trouble on the job.

We can't and won't cut the corners that shorten the quality of "Double Diamond" Gears. We believe you want it that way. We believe you want gears that do credit to the product in which you install them. We believe you want gears that give you the best, and in the long run, the *biggest* economy—the economy of a low installation cost, plus the economy of service-free performance. We believe you want, in this increasingly competitive market, the kind of gears that help you create a sound product that sells, that serves, that satisfies.

"Double Diamonds" are made to measure up to those beliefs and are always delivered to you with the honest conviction that — *everything* considered — you could make no better buy in gears.

Your inquiries will receive prompt attention — by mail or personal visit, as you prefer.

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TRADE MARK
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Made by
Automotive Gear Works, Inc.
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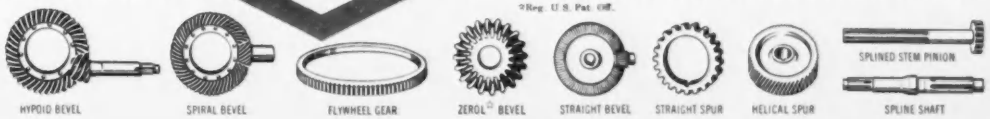

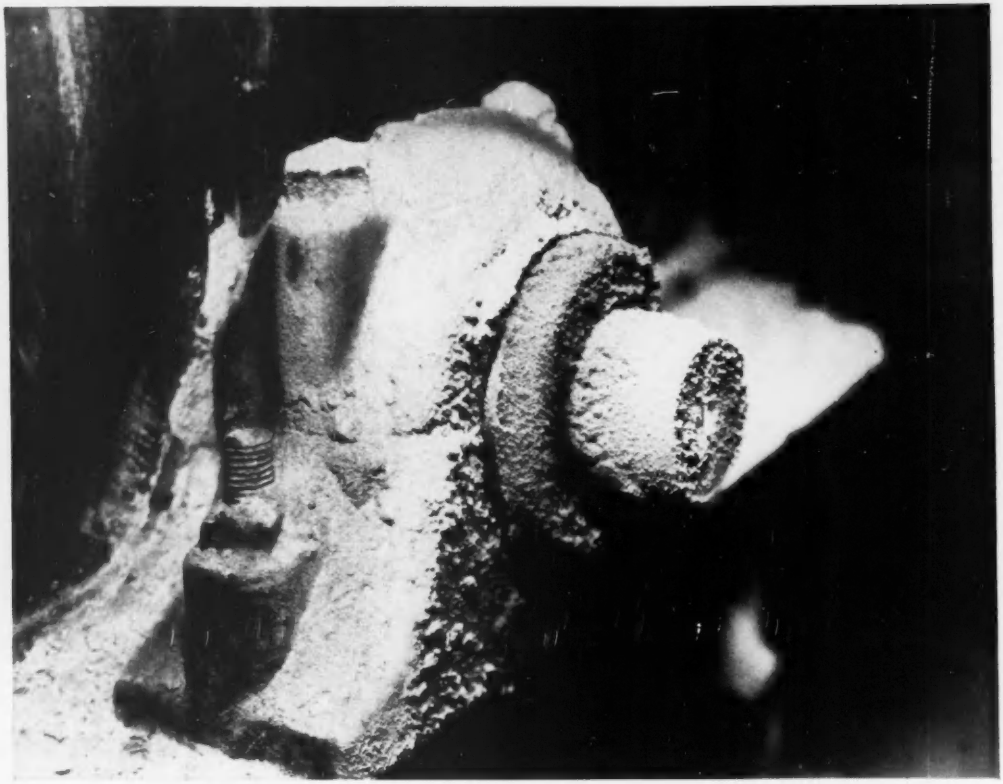

DEFIES ABRASIVE DUSTS!

The Famous Dodge-Timken Type C Bearings in Your Plant Assure Uninterrupted Production

POSITIVE TRIPLE SEAL —ANOTHER DODGE "FIRST"

WHEN you grind steel, cement, iron or rock you get dust — powdery, abrasive dust that seeps everywhere—except into Dodge-Timken Type C bearings like the one pictured above, which keeps the mill on which it is installed running smoothly at 3000 r.p.m.!

Wherever you have operating conditions of extreme dust and dirt, standardization on the Type C is your answer. Triple steel seals keep the lubricant in and the dirt out of this bearing, and in thousands of installations Dodge-Timken Type C pillow blocks are operating successfully under adverse conditions where other bearings failed. Rugged in construction, fully self-aligning, with both radial and thrust, carrying capacity, Type C is suitable for heavy line shaft service as well as many machine applications.

For complete information concerning this bearing and other Dodge "Firsts" in power drive equipment call a Transmissioneer—your local Dodge Distributor. Look for his name under "Power Transmission Equipment" in your classified telephone directory.

DODGE MANUFACTURING CORPORATION, MISHAWAKA, IND.

DODGE

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The Transmissioneer is a graduate of an intensive training course at the Dodge factory. He can help you find the answer in applying power to the job.

NAME PLATES

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This extremely heavy, heat-resistant handle is used on the Wagner Mfg. Company's Magnalite cookwear line and withstands oven temperatures reaching 500°.

HANDLES WITH CARE!

The teakettle handle for the Aluminum Cooking Utensil Co. of New Kensington is furnished completely assembled—with right and left halves, red thumb pad, moulded-in inserts consisting of speed clips, aluminum stamped links and spring.

The sales appeal of this VitaCraft stamped aluminum 2-quart pan is enhanced by the typical characteristics of this phenolic handle—by smooth pleasant feel, non-conduction of heat and gleaming appearance.

Let us give you a hand with your handles—good, durable custom-moulded pot and pan handles are a Kurz-Kasch specialty, as these three different specimens attest. All three do their share in winning the markets that these quality products enjoy. They're as acceptable cost-wise as they are performance-wise—they're phenolic, plunger-moulded in high-capacity 8 & 10-cavity presses.

We also produce a fine line of stack handles and knobs. For full information on plastics—for any product that can be plunger, transfer or compression moulded—consult your local Kurz-Kasch office or write the factory. We offer complete facilities and a pioneer achievement record second to none.

Kurz-Kasch, Inc. • 1427 South Broadway • Dayton 1, Ohio

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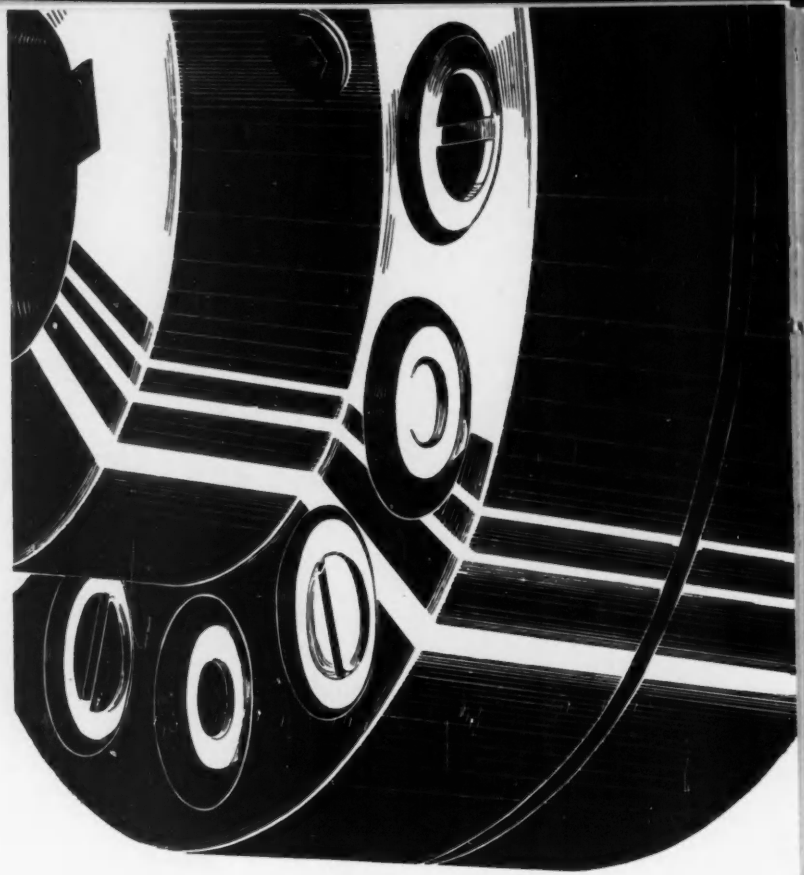
FOR OVER 33 YEARS, PLANNERS AND MOULDERS IN PLASTICS

AJAX

FLEXIBLE COUPLINGS *with* NEOPRENE BUSHINGS



In addition to the ability of Ajax Flexible Couplings to perform under difficult conditions of abrasive-laden air . . . they are available with Neoprene Bushings . . .

for

UNINTERRUPTED PERFORMANCE ON INSTALLATIONS INVOLVING OIL AND MANY CHEMICALS

● Design engineers are adding new and greater dependability and economy to their direct-connected machines by using Ajax Flexible Couplings with Neoprene Bushings. They reduce shut downs in chemical, oil, power generation, and many other locations where liquids or air-borne fumes are a problem. Write for complete information on why and how you can do it better with Ajax Flexible Couplings.

AJAX FLEXIBLE COUPLING CO. INC., WESTFIELD, N. Y.

Stock Sizes or Specials?

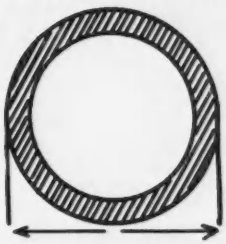
THE trend, in recent years, among leading designers of machinery and equipment is to use standard stock parts rather than specials wherever possible. And there is sound reasoning behind this move, particularly in cast bronze sleeve bearings.

Naturally in some instances it is essential to design and produce a special bearing for a specific application. Such factors as flanges, wall thickness, taper, special alloys and other characteristics that cannot be provided for in stock bearings can only be secured through special manufacturing operations. This often necessitates special patterns, tools, dies or other equipment not included in the cost of stock items. With the exception of long production runs of one size, special bearings are more costly than stock items.

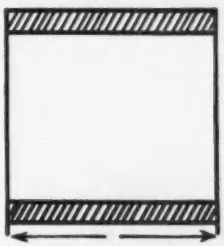
The factors that favor the designer in working to standard stock bearings are many. First, he has an unusually large range of sizes from which to make his choice. At the present we list over 850, comprised of 55 inside diameters, ranging from $\frac{1}{4}$ inch to $4\frac{1}{4}$; 55 outside diameters $\frac{3}{8}$ to $4\frac{1}{2}$; 46 lengths ranging from $\frac{3}{4}$ to $9\frac{3}{4}$. Thus it is possible to secure practically any size combination desired.

Standard stock bearings are cast in what is usually referred to as a general purpose alloy, providing better than average physical properties assuring long life and excellent performance. Oil grooves, slots, or holes are easily, quickly and economically added. Standard tolerances, as listed below, can easily be altered where closer precision is required or where greater clearance is necessary.

55 Inside Diameters



55 Outside Diameters



46 Lengths

Stock bearings are lower in cost, too, a very important feature in today's market. By making long runs of each size we are able to secure a low unit cost, which saving is passed on to the user. There is no charge for patterns or tools. Complete stocks of all sizes are always maintained providing immediate delivery in any quantity. This eliminates the necessity for maintaining extensive inventory yet provides immediate service.

Engineering Service

It has always been the policy of the Johnson Bronze Company to work with customers in order to give them the greatest value for their money when purchasing bearings. In many cases we have found that a very slight change in bearing specifications or a slight alteration of a stock bearing will give the user the full benefits of this stock bearing service. We can also help you determine the correct type of bearing for each application. As we manufacture all types of Sleeve Bearings, we base all of our recommendations on facts, free from prejudice. Why not take full advantage of this free service?

●

This bearing data sheet is but one of a series. You can get the complete set by writing to—

CATALOGUE —*Lists and describes the most complete stock bronze sleeve bearing service on the market. Its more than 80 pages are filled with helpful bearing data. Write for free copy.*

Tolerances

Years of constant study of the bearing requirements of machinery builders have not only guided the selection of the sizes to stock as standard but have also governed the decision on the proper tolerances to standardize on. We find the following most acceptable:

Outside Diam. up to 3"....plus .002" to .003"
Outside Diam. above 3"...plus .003" to .005"

All Inside Diameters.....plus or minus .001"
All Lengths.....plus or minus .005"

Johnson Bronze
SLEEVE BEARING HEADQUARTERS
508 S. MILL ST. • NEW CASTLE, PENNA.

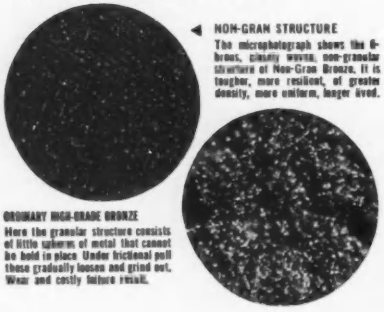
better than an aspirin . . .

NON-GRAN BRONZE

the metal that wears IN *while others wear* OUT

Headaches vanished for the maker of a water filter pump who experienced trouble with steel cams, thanks to Non-Gran. The replacement of these parts was necessary within each 12 month period. Corrosion being coupled with wear. We corrected the trouble by casting the cams of Non-Gran Bronze so nearly to size that only a file-fit was necessary. Costly machining was eliminated. Service life extended indefinitely. Rust licked!

We welcome your request to help with any problem concerning bronze casting or the machining of parts in any metal to aircraft tolerances. We have worked with manufacturers in diversified fields for 40 years. Request detailed literature.



NON-GRAN STRUCTURE
The microphotograph shows the fibrous, closely woven, non-granular structure of Non-Gran Bronze. It is tougher, more resilient, of greater density, more uniform, longer lived.

ORDINARY HIGH-GRADE BRONZE
Here the granular structure consists of little spherules of metal that cannot be held in place. Under frictional pull these gradually loosen and grind out. Wear and costly failure result.

PHYSICAL CHARACTERISTICS OF NON-GRAN BRONZE

Ultimate Tensile	40,000 psi
Yield Point	22,000 psi
Proportional Limit	11,500 psi
Elongation in 2 in.	15%
Reduction of area	11%
Modulus of Elasticity	13,000,000
Ultimate Compression	50,000 psi
Ultimate Shear	45,000 psi
Linear coefficient of thermal expansion	.000011
Brinell Hardness	80

(10 mm ball, 500 KG load, thirty seconds)

American NON-GRAN Bronze Company
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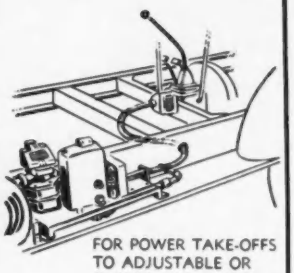
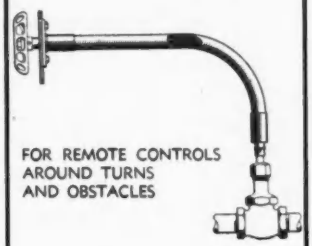
Elliott FLEXIBLE SHAFTING



FOR POWER TAKE-OFFS TO ADJUSTABLE OR OUT-OF-LINE PARTS



FOR REMOTE CONTROLS AROUND TURNS AND OBSTACLES

Elliott ENGINEERING AND DESIGN SERVICE

Backed by 50 years of experience in the Flexible Shaft and related fields, the Elliott engineering staff is constantly incorporating new and modern improvements in the design of their own equipment. This staff is available to you, as a part of the Elliott Service, to cooperate in working out the details of your own problems. We will be pleased to supply Flexible Shaft Data Sheets on request. These will aid you in furnishing us with certain necessary specifications such as r.p.m., torque, deflection, etc.

Write for Catalog 49 on your Company Letterhead

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MANUFACTURING COMPANY
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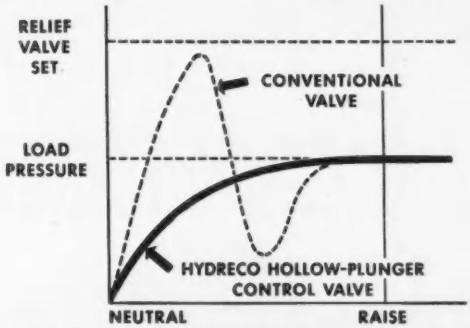
Smooth

OUT THOSE PEAKS AND VALLEYS in your hydraulic systems with the

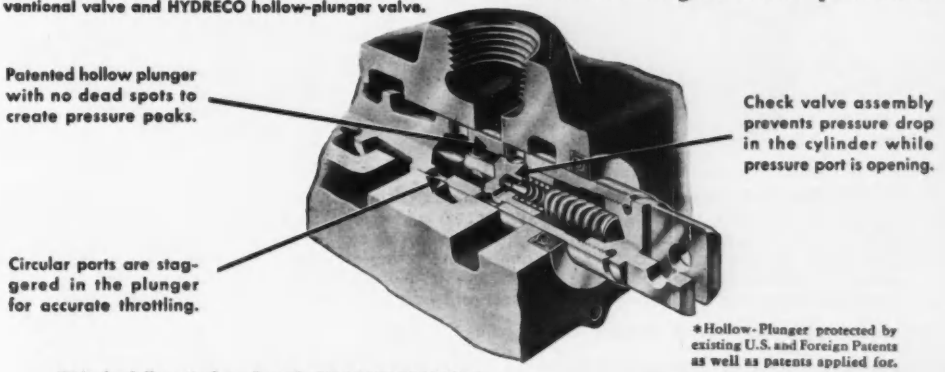
HYDRECO HOLLOW-PLUNGER* CONTROL VALVE



Graph of pressure rise during plunger travel for both conventional valve and HYDRECO hollow-plunger valve.

THAT HOLDS THE LOAD WHILE THE OPERATING POSITIONS ARE CHANGED

In the HOLLOW-PLUNGER control valve, with built-in checks, the cylinder port opens before the neutral port is closed—without dropping the load. Constant pressure rise, from neutral to full operating position, favors careful throttling or *smooth* quick action.


Patented hollow plunger with no dead spots to create pressure peaks.
Check valve assembly prevents pressure drop in the cylinder while pressure port is opening.
Circular ports are staggered in the plunger for accurate throttling.

*Hollow-Plunger protected by existing U.S. and Foreign Patents as well as patents applied for.

Write for full particulars about the HOLLOW-PLUNGER control valve—made by HYDRECO only—to

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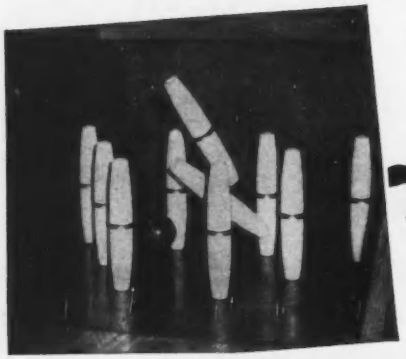
HYDRECO
HYDRAULIC CONTROL DEVICES
PUMPS · CYLINDERS · VALVES

"PLASTICS are *Right* if they're *Molded by Northern*"

The Durable Bowling Pin Corporation decided to be the first to dress up wood pins in tough plastic. To do a job that had never been done before they selected Northern. They knew that Northern had not only the facilities, but the designing, engineering and molding experience that is so essential for just such pioneering jobs.

Northern experts are familiar with *all* compounds, know *how* and *when* to use them, and the best way to mold *each* one, Northern made good its promise to add good looks and longer life to bowling pins. Ethyl cellulose was the material used. What is *your plastic* problem?



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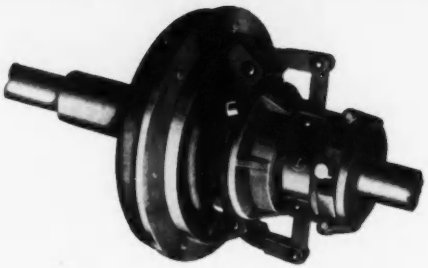
JONES-LEMLEY FRICTION CLUTCHES



JONES-LEMLEY friction clutches are built for a broad range of shaft sizes and ratings in both enclosed and open types for sleeve and coupling work. In addition they are available in a line of Jones-Lemley friction clutch pulleys. This clutch modification is also used for gears, V-belt sheaves, sprocket wheels, etc. Sizes, ratings, dimensions, prices and other data are contained in Bulletin No. 60. Your request will bring a copy.

W. A. JONES FOUNDRY & MACHINE CO., 4417 Roosevelt Rd., Chicago, Ill.

Jones

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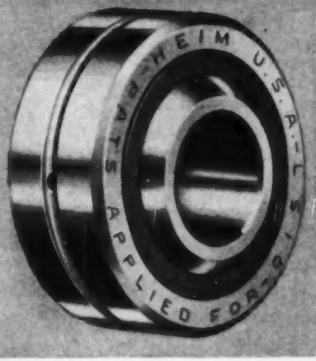
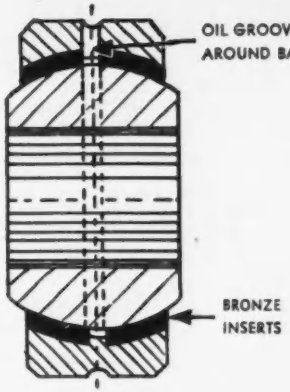
CUT AND MOLDED TOOTH GEARS • V-BELT SHEAVES • ANTI-FRICTION
PILLOW BLOCKS • FRICTION CLUTCHES • TRANSMISSION APPLIANCES

"An amazing new bearing principle"

HEIM
UNIBAL SPHERICAL BEARING



Besides the spherical bearing, there is also the spherical bearing rod end for use wherever motion is to be transferred at any angle and where radial and axial loads are too heavy for the conventional type of bearing.



Instead of a row of balls operating in a race, the Heim Spherical Bearing is a single ball with large contact area provided for misalignment in all directions. Its freedom of movement can best be described by comparison with an eyeball in its socket. The outer casing is usually of carbon steel, but any other material may be used. The single ball is made from SAE 52100 chrome steel, heat treated, and is provided with a super finish. The bearings can be furnished in a wide range of sizes. The ball rotates in a bronze bearing which has been expanded over the ball into interlocking relation with the outer member. Ample provision is made for lubrication.

Write for Illustrated Catalog.

THE HEIM COMPANY
FAIRFIELD CONNECTICUT

S.S. White

FLEXIBLE SHAFTS SIMPLIFY DESIGN

WHEN YOU NEED A CONTROL FOR AN INACCESSIBLE VALVE . . .

Opening and closing the drain valve on the bottom of an automobile crankcase was made easy by connecting an S.S.White remote control flexible shaft to the valve stem and placing the control handle in a handy location under the hood.

THE above example is typical of the way in which S.S.White flexible shafts simplify and improve designs. In this case, a seemingly complicated problem was solved by a single, self-contained flexible shaft—no gears, pulleys, universal joints or other mechanical elements were needed. Can you think of an easier way to provide an inaccessible part with a conveniently operated control?

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It contains 260 pages of information and data on flexible shaft selection and application. Free copy sent if you write for it on your business letterhead.

S.S.White MAKES IT RIGHT

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO. — DEPT. D — 10 EAST 40th ST., NEW YORK 16, N. Y.

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MOLDED PLASTICS PRODUCTS—MOLDED RESISTORS

One of America's AAAA Industrial Enterprises

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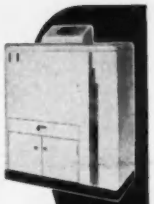
Our expert field engineers are ready to discuss your problem in your plant.



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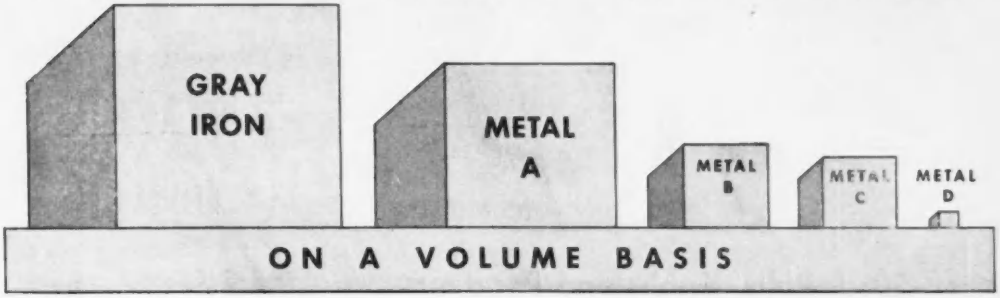
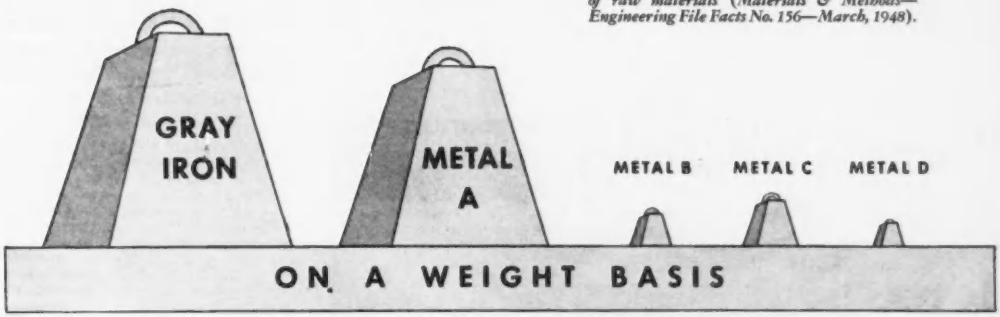


Comparisons in these charts based on the costs of raw materials (Materials & Methods—Engineering File Facts No. 156—March, 1948).



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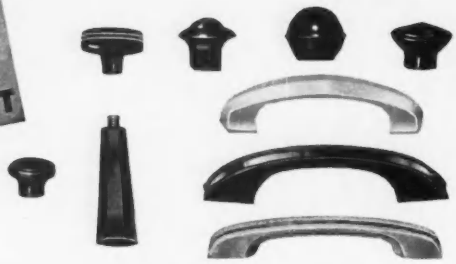

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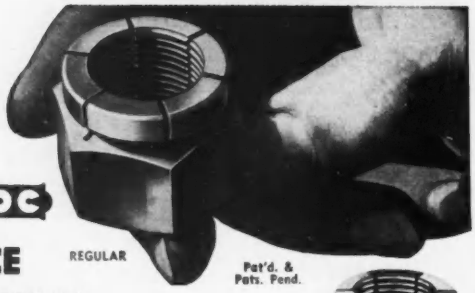

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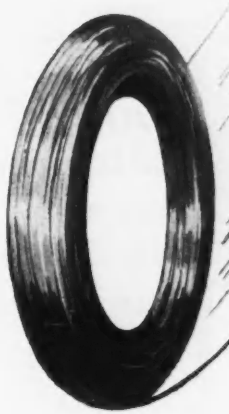

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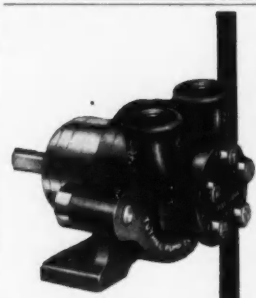

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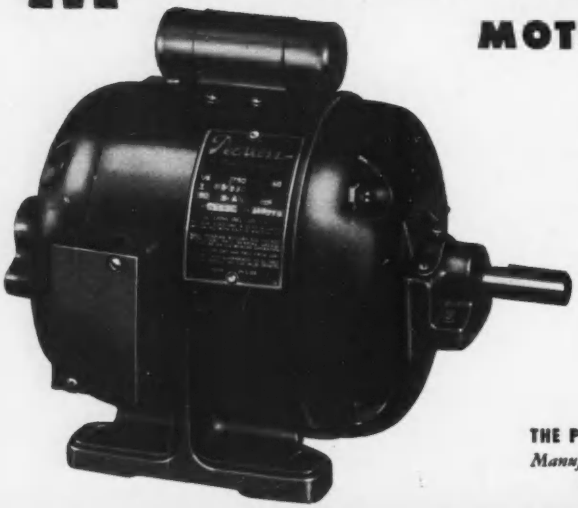

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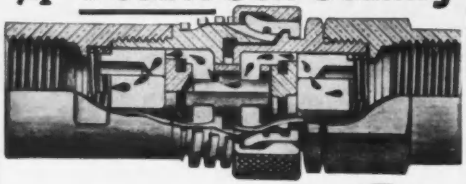

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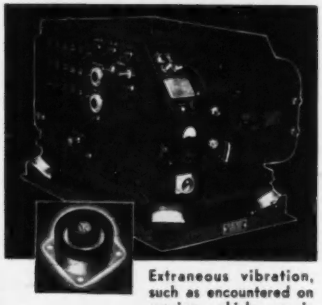

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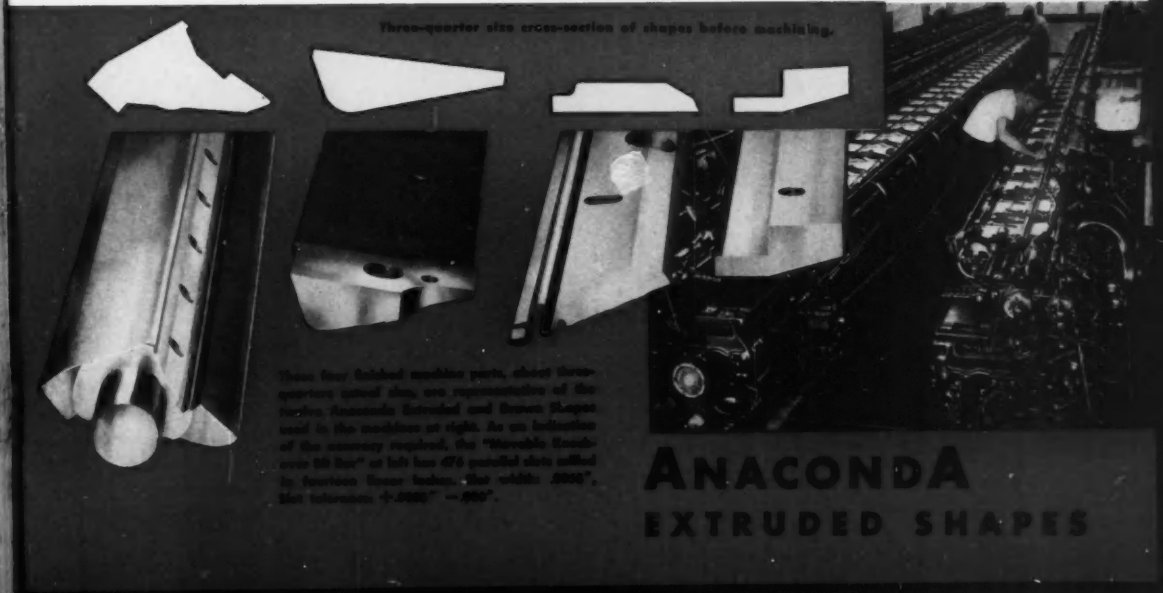

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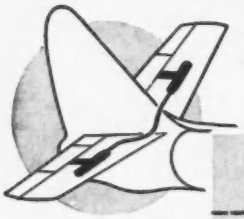
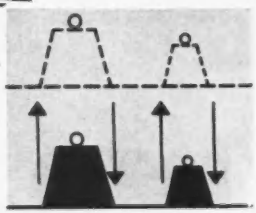


TWIN *Lineator* for synchronized aircraft tab control



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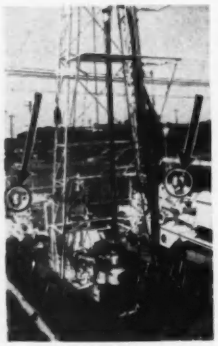

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The features you get with Mayari R

This versatile high-strength, low-alloy steel is helping to improve the designs of a great variety of products including railroad cars, motor vehicles, industrial equipment, fabricated structures and household items. For full information on the properties and applications of Mayari R write for a copy of Catalog 259.

BETHLEHEM STEEL COMPANY
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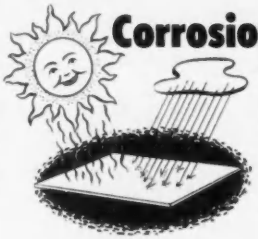
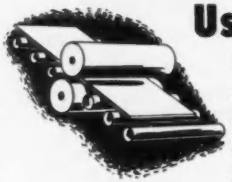
High strength

The 50,000 psi minimum yield point of Mayari R is approximately double that of plain carbon steel, permitting higher working stresses.



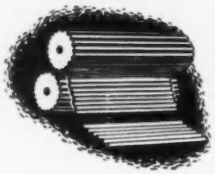
Corrosion-resistance

The atmospheric corrosion-resistance of Mayari R is 5 to 6 times that of plain carbon steel and 2 to 4 times that of copper-bearing steel.



Used as-rolled

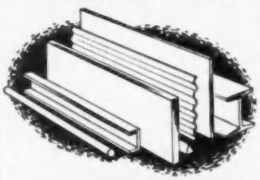
It has advantages of alloy steel without the expense of heat-treatment. Mayari R can be worked hot or cold in the as-rolled condition.



Workability

Mayari R can be formed, sheared, punched, drilled, and welded by the methods used for carbon steel.

Available in many forms



Mayari R is produced in sheets, strip, plates, bars, structural shapes, and cold-formed shapes.

Comparatively low cost

The initial cost of Mayari R is little more than that of carbon steel. This difference is frequently offset by savings in deadweight and maintenance.

Mayari R *makes it lighter... stronger... longer lasting*

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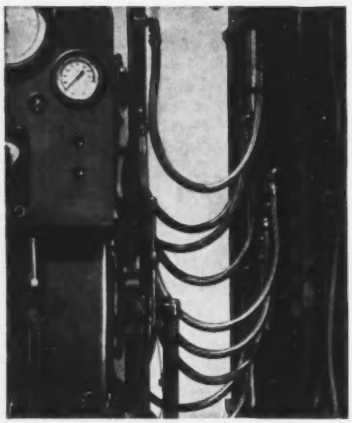

Steam to the moving platens of this hot plate press, made by Williams, White & Co., of Moline, Ill., is carried through these ½" I. D. Bronze American Seamless Flexible Metal Connectors.

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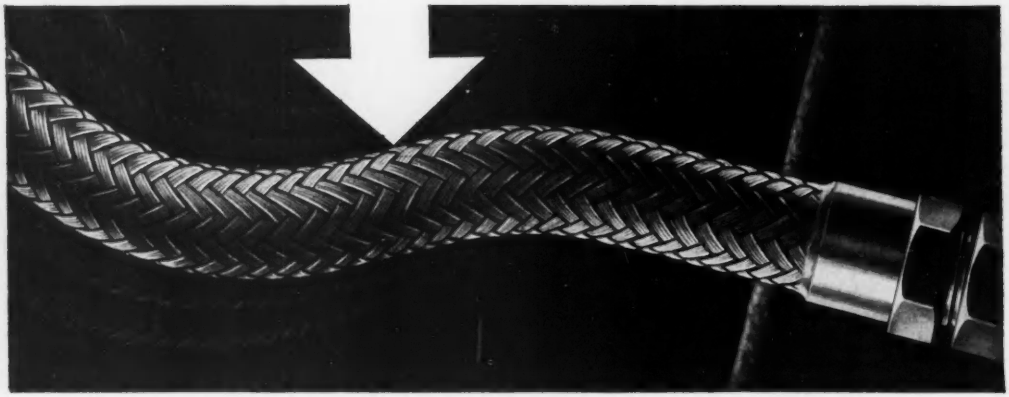

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